

MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOLUME XXIX, 1937

CONSISTING OF I-V—743 PAGES,
INCLUDING FIGURES; ALSO 1 PORTRAIT
AND 2 PHOTO-GELATINE PLATES

LANCASTER PRESS, INC.. LANCASTER, PA.

TABLE OF CONTENTS

No. 1. JANUARY-FEBRUARY

| | |
|-----------------------------------------------------------------------------------------------------------------|-----|
| Historical background of the Mycological Society of America, HARRY M. FITZPATRICK..... | 1 |
| Notes on Chinese Cercosporae, CHARLES CHUPP AND DAVID H. LINDER.. | 26 |
| Dipodascus uninucleatus, ROSEMARY BIGGS..... | 34 |
| New and unusual agarics from western United States, ALEXANDER H. SMITH..... | 45 |
| Photographs and descriptions of cup-fungi—XXV. <i>Urnula</i> Geaster, FRED J. SEAVER..... | 60 |
| Three Dermateaceae occurring on <i>Nemopanthus</i> , J. WALTON GROVES... | 66 |
| A new species of <i>Phialea</i> on alder seeds, J. R. KIENHOLZ AND EDITH K. CASH..... | 81 |
| Nature of variation in <i>Helminthosporium sativum</i> , J. J. CHRISTENSEN AND F. R. DAVIES..... | 85 |
| Cytological studies in the Tremellaceae. IV. <i>Protodontia</i> and <i>Tremellodendron</i> , R. M. WHELDEN..... | 100 |
| Observations on sexual relations in <i>Hypomyces</i> <i>Ipomoeae</i> , A. W. DIMOCK | 116 |
| <i>Septotinia</i> , a new genus of the <i>Ciborioideae</i> , H. H. WHETZEL..... | 128 |
| Notes and brief articles..... | 147 |

No. 2. MARCH-APRIL

| | |
|-----------------------------------------------------------------------------------------------------------------------------------|-----|
| The nuclear history of <i>Sclerospora graminicola</i> , E. S. McDONOUGH..... | 151 |
| Photographs and descriptions of cup-fungi—XXVI. The genus <i>Diplocarpa</i> , FRED J. SEAVER..... | 174 |
| A new species of <i>Phlyctochytrium</i> on <i>Hydrodictyon reticulatum</i> , J. S. KARLING..... | 178 |
| Crozier formation in the <i>Gymnoascaceae</i> : a preliminary note, EDWARD D. DELAMATER..... | 187 |
| Undescribed species of <i>Cercospora</i> and <i>Cercospora</i> on certain grasses in Oregon and Washington, RODERICK SPRAGUE..... | 199 |
| A new species of <i>Candelospora</i> causing decay of citrus fruits, H. S. FAWCETT AND L. J. KLOTZ..... | 207 |
| A fungus on lace bugs, VERA K. CHARLES..... | 216 |
| A new species of <i>Magnusia</i> , L. M. AMES..... | 222 |
| Some sporangial variations in <i>Saprolegnia ferax</i> , FRED T. WOLF..... | 226 |
| New <i>Zoöpagaceae</i> destructive to soil rhizopods, CHARLES DRECHSLER... | 229 |
| New species of <i>Hyphomycetes</i> , DAVID R. SUMSTINE..... | 250 |
| Lime-loving molds from Australian sands, CHARLES L. PORTER AND GEORGE ZEBROWSKI..... | 252 |
| Additional data on sex reactions in monospore races of <i>Neurospora tetrasperma</i> , BERNICE SEAVER..... | 258 |
| Notes and brief articles..... | 266 |

NO. 3. MAY-JUNE

| | |
|------------------------------------------------------------------------------------------------------------|-----|
| Hybridization studies on a zinc-induced variant of <i>Hypomyces</i> <i>Ipomoeae</i> , A. W. DIMOCK..... | 273 |
| Two Canadian collections of <i>Cantharellus multiplex</i> , IRENE MOUNCE AND HENRY A. C. JACKSON..... | 286 |
| Hydrogen ion concentration and ascus formation, LEWIS B. LOCKWOOD.. | 289 |
| Pascher and the genus <i>Asterocystis</i> of DeWildeman, J. S. KARLING.... | 291 |
| Observations on a <i>Monascus</i> isolated from rubber, ARTHUR L. SCHADE.. | 295 |
| <i>Cenangium molliusculum</i> , EDITH K. CASH..... | 303 |
| The perfect stage of <i>Botrytis convoluta</i> , F. L. DRAYTON..... | 305 |
| Mimicry in <i>Hypoxylon</i> , WILLIAM W. DIEHL..... | 319 |
| A new species of <i>Dothiorella</i> causing die-back of elm, A. F. VERRALL AND CURTIS MAY..... | 321 |
| A new species of <i>Tuberaceae</i> for America, CLOYD BURNLEY STIFLER.... | 325 |
| Sporulation of the <i>Phialophora</i> type in <i>Hormodendrum</i> , C. W. EMMONS AND A. L. CARRION..... | 327 |
| Photographs and descriptions of cup-fungi—XXVII. <i>Pezicula</i> on Cornus, FRED J. SEAVER..... | 334 |
| Studies in the genus <i>Mycena</i> . IV, ALEXANDER H. SMITH..... | 338 |
| Mycological notes. I, C. L. SHEAR..... | 355 |
| Notes and brief articles..... | 364 |

NO. 4. JULY-AUGUST

| | |
|--------------------------------------------------------------------------------------------------------------------|-----|
| Microaerophilic strains of <i>Actinomyces</i> isolated from tonsils, C. W. EMMONS..... | 377 |
| Phototropic response of perithecial necks in <i>Neurospora</i> , MYRON P. BACKUS..... | 383 |
| First Canadian record of <i>Aleurodiscus subcruentatus</i> , MILDRED K. NOBLES..... | 387 |
| Notes on the Mycetozoa—I, ROBERT HAGELSTEIN..... | 392 |
| Observations on the comparative morphology and taxonomic relationships of certain smuts, GEORGE W. FISCHER..... | 408 |
| New or noteworthy parasitic species of Fungi Imperfecti in Oregon, RODERICK SPRAGUE..... | 426 |
| Notes on the parasitic fungi of Illinois—VI, LEO R. TEHON..... | 434 |
| Some Hyphomycetes that prey on free-living terricolous nematodes, CHARLES DRECHSLER..... | 447 |
| Notes and brief articles..... | 553 |

NO. 5. SEPTEMBER-OCTOBER

| | |
|-----------------------------------------------------------------------------------------------------------------------------------|-----|
| Production of conidia by <i>Corticium incrustans</i> , MILDRED K. NOBLES... | 557 |
| The cultural characteristics of <i>Fomes connatus</i> , W. A. CAMPBELL..... | 567 |
| <i>Eidamella spinosa</i> (Matruchot and Dassonville) refound, EDWARD D. DELAMATER..... | 572 |
| Miscellaneous notes on the Ustilaginales, GEORGE L. ZUNDEL..... | 583 |
| Notes on the genus <i>Micromyces</i> , JOHN N. COUCH..... | 592 |
| The occurrence of a human pathogenic fungus as a saprophyte in nature, NORMAN F. CONANT..... | 597 |
| Studies of certain species of <i>Melanconis</i> on <i>Carpinus</i> , <i>Ostrya</i> and <i>Corylus</i> , LEWIS E. WEHMEYER..... | 599 |

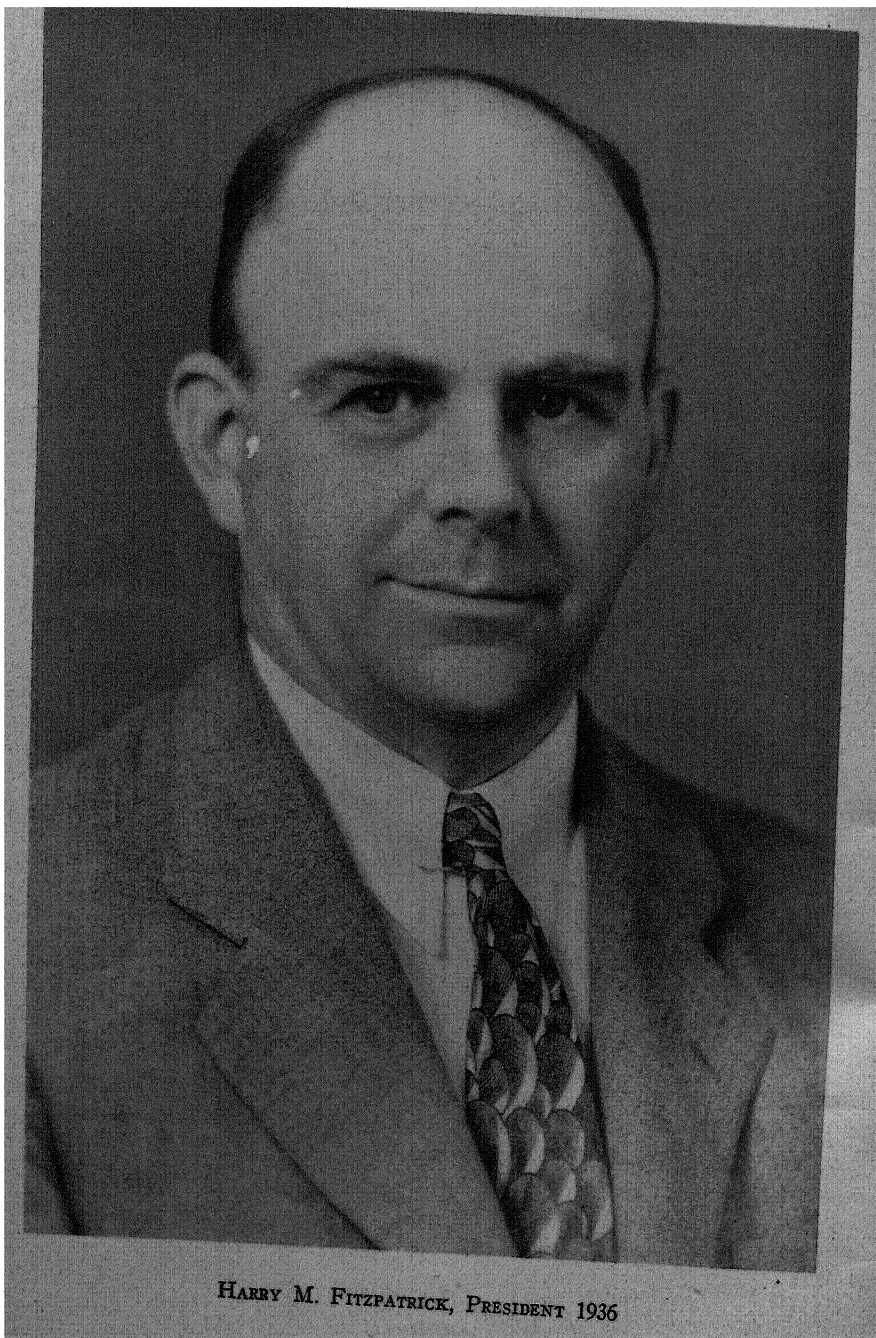
TABLE OF CONTENTS

v

| | |
|-------------------------------------------------------------------|-----|
| New or noteworthy fungi from Panama and Colombia. I, G. W. MARTIN | 618 |
| Studies in the sexuality of the Heterobasidiae, HORACE L. BARNETT | 626 |
| Notes and brief articles | 650 |

NO. 6. NOVEMBER-DECEMBER

| | |
|----------------------------------------------------------------------------------------------------------|-----|
| The conidial stage of <i>Peziza pustulata</i> , B. O. DODGE | 651 |
| New Venezuelan Fungi Imperfecti, DAVID H. LINDER | 656 |
| A new fungus intermediate between the rusts and <i>Septobasidium</i> , JOHN N. COUCH | 665 |
| A new species of <i>Cordyceps</i> with notes concerning other species, E. B. MAINS | 674 |
| Photographs and descriptions of cup-fungi—XXVIII. A proposed genus, FRED J. SEAVER | 678 |
| A decay of ornamental cacti caused by <i>Aspergillus alliaceus</i> , J. J. TAUBENHAUS AND G. E. ALTSTATT | 681 |
| The species concept in <i>Corticium coronilla</i> , ROSEMARY BIGGS | 686 |
| The perithecial cavity formation in a <i>Leptosphaeria</i> on <i>Opuntia</i> , B. O. DODGE | 707 |
| Notes on the synonymy of French and American Agarics—I, MARCEL JOSSERAND AND ALEXANDER H. SMITH | 717 |
| <i>Coryneum microstictum</i> on rose from Oregon, ANNA E. JENKINS | 725 |
| Notes and Brief Articles | 732 |
| Index to volume XXIX | 733 |



HARRY M. FITZPATRICK, PRESIDENT 1936

MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOL. XXIX

JANUARY-FEBRUARY, 1937

No. 1

HISTORICAL BACKGROUND OF THE MYCOLOGICAL SOCIETY OF AMERICA

HARRY MORTON FITZPATRICK¹

(WITH PORTRAIT AND 5 FIGURES)

Five years ago, in December, 1931, at New Orleans, the Mycological Society of America was voted into existence. Our business session this morning recalls clearly the first meeting of the Society the following winter, when here at Atlantic City at the Hotel Traymore, December 28, 1932, we completed our organization and adopted *Mycologia* as our official organ of publication. In the few years that have followed, the advantages that are ours as members of an exclusively mycological society have become increasingly manifest. Doubtless in another decade our younger members will have come to regard these advantages as their natural heritage, knowing little of and giving little thought to the problems which confronted American mycologists in earlier years.

Having been long interested in the history of mycology, having served as an officer of our Society during these first five years through what I am pleased to call its formative period, and with the thought that our fifth anniversary should not pass wholly unnoticed, I have prepared for this occasion a paper entitled, *Historical Background of the Mycological Society of America*. It

¹ Address of the Retiring President of the Mycological Society of America, given at the Atlantic City meeting, December 29, 1936.

[*MYCOLOGIA* for November-December (28: 497-633) was issued
December 1, 1936]

has interested me to review the activities of the Mycological Section of the Botanical Society of America, from which our Society took origin, and to learn all that I could of the older American Mycological Society which lost its identity in 1906 by merging with the Botanical Society. And in order that the record of the organized activities of American students of the fungi might be made more complete I have brought together the pertinent available information concerning the national organizations of wider scope with which mycologists were affiliated during earlier years. It has not seemed to me desirable to incorporate material concerning local societies, though some of them have existed for many years and have had a very considerable influence. Presenting the material in chronological sequence, I shall endeavor to picture the changing situation, which has confronted American mycologists throughout the years as they have sought to meet for consideration of their mutual problems and for presentation of the results of their research. In closing I shall indicate the events which led to the formation of our Society, and shall sketch briefly the essential features of the first five years of its history. I trust that you will regard this subject as appropriate for the address required by the Society of its Retiring President.

ASSOCIATION OF AMERICAN GEOLOGISTS AND NATURALISTS

Nearly one hundred years ago on the second day of April, 1840, eighteen men, interested primarily in geology, held a meeting in the rooms of the Franklin Institute in Philadelphia, which was to have a far reaching influence on the development of science in this country (1, p. 9; 2, vol. 52, p. 15). Impressed by the need for coöperation among American scientists, they unanimously resolved to organize themselves into a national association to be called The Association of American Geologists. Though ten of these eighteen charter members were residents of Philadelphia, the others represented the states of New York, New Jersey, Massachusetts, Connecticut, Virginia, and Michigan. At their third meeting in 1842, at the time of adoption of a constitution and by-laws, the name of the organization became The Association of American Geologists and Naturalists. Its objectives were then stated to be "the advancement of geology and the collateral

branches of natural science and the promotion of intercourse between those who cultivate them" (1, p. 77). At that time the membership of the Association had grown to seventy-seven and a volume of Transactions covering the first three meetings was published. The Association was in existence only eight years. Its recorded programs indicate that the interests of its members were predominatingly geological. Botanical material was presented, some of it on fossil plants, but so far as I have been able to determine no dissertation was ever given on any mycological subject. Our only interest in the organization lies in the fact that in September, 1847, in Boston at the eighth and last meeting of the Association a resolution was adopted by which the body agreed to resolve itself into an organization of wider scope to bear the name American Association for the Advancement of Science.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

The first meeting of the Association under the new name was held in the rooms of the Academy of Natural Sciences at Philadelphia, September 20, 1848. Rules adopted there state: "The objects of the Association are, by periodical and migratory meetings, to promote intercourse between those who are cultivating science in different parts of the United States; to give a stronger and more general impulse, and a more systematic direction to scientific research in our country; and to procure for the labours of scientific men, increased facilities and a wider usefulness."

The list of 461 charter members published in the Proceedings of the first meeting contains the names of several botanists including those of John Torrey and Asa Gray, but no botanical material appeared on the program the first year. At this first meeting a Section of Natural History and Geology was organized, and Professor Louis Agassiz was selected to preside (2, vol. 1, p. 26). He immediately suggested that at each day's session a new chairman be chosen, in order that no individual be wholly prevented from attending other sections. That procedure was followed thereafter for a considerable period of years.

At the second meeting, held at Cambridge, Massachusetts, in August, 1849 (2, vol. 2, p. 12), the first botanical paper was presented before the Association. It was read by Professor Asa

Gray for the author, Major Benjamin Alvord of the United States Army, and dealt with *Silphium laciniatum*, a plant of the western plains, in which the leaves were said to be so oriented as to point always exactly north or south. This definite polarity was regarded by the Major as due in some way to the action of magnetism, and he applied the name polar plant. He explained that the plant had been called to his attention by the well known scout Major Nathan Boone, son of the celebrated Daniel Boone. Pro-

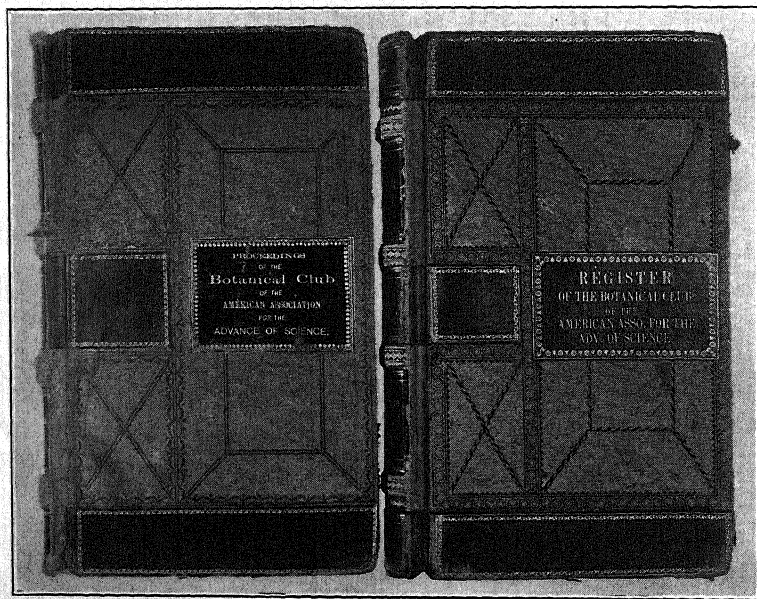


FIG. 1. Proceedings and Register of the Botanical Club of the American Association for the Advancement of Science. Large leather-bound books used throughout the entire life of the organization.

fessor Gray, having grown the plant in his botanical garden at Cambridge, and having failed to observe the polarity claimed for the species, was inclined to disregard the Major's observations.

At the third meeting of the Association held at Charleston, South Carolina, in March, 1850, the first paper containing mycological material made its appearance on the program (2, vol. 3, pp. 2-17). Its author, H. W. Ravenel, is known to all of us as the

early collector who distributed the exsiccati sets *Fungi Americani* and *Fungi Caroliniani*. In a paper entitled "Catalogue of Plants Inhabiting the Vicinity of the Santee Canal, South Carolina," he reported before the Association the collection of more than 2400 species of plants of all groups. He stated that he had found approximately 1000 fungi and 175 lichens, his figures being indefinite because much of the material was as yet unidentified. He says: "Although my attention has been chiefly directed for the last three years to the collection and examination of the fungi, I cannot doubt, from the ease with which new forms are continually added to my collection, the great number of different species which spring up in the same locality in different seasons, that the present number may, in the course of time, be easily doubled."

At the fifth meeting in 1851, George C. Schaeffer of Danville, Kentucky, gave a paper entitled "On the Detection of Organic Miasm in the Air." He says: "It is now the opinion of most chemists who have investigated the subject that malaria is caused, not by peculiar states of the atmosphere, but by some complex organic compound floating in it" (2, vol. 5, p. 239).

Twenty years passed before in 1870 the second mycological paper made its appearance (2, vol. 19, p. 287). In that year a lengthy but unimpressive dissertation was given bearing the title "Investigation of the Development of the Yeast or Zymotic Fungus." At the end of an additional ten years, in 1880, Thomas J. Burrill presented one of the first papers before the Association in the field of bacteriology, discussing his epoch-making work on fire-blight of pears and apples under the general title of "Anthrax of Fruit Trees" (2, vol. 29, p. 583). Byron D. Halsted appeared on the same program with a paper entitled "An Investigation of Peach Yellows" (2, vol. 29, p. 605). During these first thirty-two years of the Association's existence a total of only 48 contributions in the broad field of botany were made. The reader who scans the pages of the Proceedings of the earlier years is impressed by the fact that workers were few and papers often lacking in the precise scientific method of presentation which we have come to expect today. Nevertheless, the student with the historical turn of mind finds much to interest him and is sometimes afforded amusement.

For more than fifty years the annual meetings were held during the summer (2, vol. 52, p. 16). In the earlier years transportation facilities did not permit workers in remote regions to get together in midwinter. Most of the early meetings were held along the Atlantic seaboard, often in smaller cities than would now be selected, such as Salem, Massachusetts, Troy and Saratoga, New York, and Burlington, Vermont. The fifth meeting ventured as far west as Cincinnati and it is interesting to read of the astonishment of the members of the committee at finding adequate facilities where frontier conditions in the forest had been expected (2, vol. 5, p. 244). Nevertheless, it was not until seventeen years later, at the close of the Civil War, that the first Chicago meeting was held in August, 1868, marking the farthest point west for meetings held up to that date. Chicago, with a population of 200,000, had then just begun to forge ahead of Cincinnati. Two years earlier in 1866, with the bridging of the Hudson River at Albany, it became possible to journey from New York to Chicago by rail by changing trains and railways at several intermediate points. The first through train between the two cities did not run until 1875.

SECTION F

The Association during its earlier life, with a relatively small membership, was much less definitely organized than is the case today. The Section of Natural History and Geology, recognized at the first meeting in 1848, persisted for a period of years as an indefinite thing without permanent organization or annual officers. At times it embraced chemistry. It was not until 1882 that increase in membership and in the number of subject matter groups led to the formation of a larger number of sections designated by letters of the alphabet as at present. That year Section F was established for biology, including both botany and zoölogy, and excluding such borderline fields as microscopy, histology, anthropology, and geology which were assigned to other sections (2, vol. 31, p. 423). With the erection of this permanent organization, election of annual officers began. In Section F the offices of chairman and secretary were established. They were filled in alternate years by botanists and zoölogists respectively. The

botanists who served as chairman of the section were W. J. Beal (1883), T. J. Burrill (1885), W. G. Farlow (1887), G. L. Goodale (1889), and J. M. Coulter (1891), while the position of secretary was filled by C. E. Bessey (1884), J. C. Arthur (1886), B. E. Fernow (1888), J. M. Coulter (1890), and B. D. Halsted (1892). Zoölogical papers usually predominated on the programs but the section showed a gradually increasing botanical interest. In the broad field of botany specialization was on the increase, and a larger number of botanists with limited interests were attending the meetings. Though prior to the formation of Section F, in 1882, only two papers dealing with any phase of mycology had been presented before the Association throughout the thirty-four years of its existence, papers dealing with the fungi now became less uncommon. In 1883 W. G. Farlow discussed "The Spread of Epidemic Diseases in Plants" using *Peronospora viticola*, *P. Halstedii*, and *Puccinia malvacearum* as outstanding examples of causal organisms (2, vol. 32, p. 307). In 1885 he gave "Notes on Some Injurious Fungi of California" (2, vol. 34, p. 300), in 1886 presented "The Development of the Gymnosporangia of the United States" (2, vol. 35, p. 237) and in 1887 selected as the subject of his vice-presidential address before the section "Vegetable Parasites and Evolution" (2, vol. 36, p. 233). Meanwhile other mycological contributions were being made. In 1885 J. C. Arthur presented cultural proof of the earlier hypothesis of Burrill that "bacteria are the direct cause of the disease of trees known as pear blight" (2, vol. 34, p. 295), and Theobald Smith appeared on the program with several bacterial contributions.

THE BOTANICAL CLUB OF THE AMERICAN ASSOCIATION

In 1883, the year following the organization of section F, the Association met at Minneapolis. For botanists it was the most important meeting which had been held in America up to that date. We quote the words of John M. Coulter who reported on it in the *Botanical Gazette* (6, vol. 8, p. 291). He says: "This meeting was a memorable one for botanists, there being more in attendance than ever before, and for the first time botanical papers were in the majority in the section of biology. But after all, the interest at such a time is not so much in the papers read as in the personal

contact of the workers who may long have known each other but never had met, and for whom the clasp of the hand and the glance of the eye cements a friendship already formed. At such times beginners meet with the leaders whose names are household words, and find them genial, hearty, whole-souled men, with a cheering word for all, and they return with fresh zeal for their work."

1883.

The Botanical Club

of the A.A.A.S. was organized at the Minneapolis Meeting. It has no Constitution or by-laws. It is simply an association of botanists who are members of the A.A.A.S. for the purpose of general botanical conference and excursions during the meetings of the A.A.A.S. Prof. W. J. Beal was chosen President and Prof. J. M. Coulter Sec'y. The members enrolled at Minneapolis were: W. J. Beal, J. M. Coulter, W. G. Farlow, C. E. Bessey, J. C. Arthur, W. R. Dudley, Geo. Vasey, E. L. Sturtevant, Lillie J. Martin, Mrs. Ellen B. Reed, P. R. Hoy, N. A. Townshend, W. H. Manning, Sadie M. Manning, C. V. Riley, R. P. Bigelow, Jos. F. James, B. P. Colton, E. S. Buelin, S. A. Forbes, F. A. Gulley, Ellen, E. Smith, Leander Stone, Mrs. Leander Stone, E. W. Clappole, W. R. Lazenby, W. M. Canby, J. W. Chickering, Edw. Pennock, J. M. Holzinger.

FIG. 2. Upper half of first page of the Proceedings of the Botanical Club of the American Association.

Botanical zeal ran so high that it culminated in the formation of an American botanical club (13, p. 1), established to foster general botanical conferences and excursions during the meetings of the American Association. Its membership consisted thereafter of the botanists attending these meetings. Formal organization with the adoption of a constitution and by-laws was never undertaken. Thirty members, representing thirteen different states, enrolled the first year at the Minneapolis meeting. The

Club elected W. J. Beal as its first president and J. M. Coulter as its first secretary. The following year at the Philadelphia meeting it entered enthusiastically on its work (6, vol. 9, p. 156). The local botanists of Philadelphia presented the organization with a large leather-bound blank register in which for many years thereafter it was the custom for all individuals attending the sessions to sign their names (FIG. 1). Its pages for those early years bear the signatures of Asa Gray, E. W. D. Holway, F. Lamson-Scribner, N. L. Britton, Charles Bessey, T. J. Burrill, L. M. Underwood, J. C. Arthur, and other outstanding botanists of the period (FIG. 3). An essentially identical companion volume was purchased to receive the Proceedings of the meetings (FIG. 1, 2). The Botanical Club was active for more than twenty years (4, vol. 13, p. 108; vol. 23, p. 350; 6, vol. 9, p. 156; vol. 45, p. 424; 13). It held its last meeting in Philadelphia in 1904, J. H. Barnhart being its last secretary and treasurer. The two volumes constituting its Proceedings and Register were then deposited with the Botanical Society of America, and became a part of the archives of that Society. They are now in the possession of its secretary.²

Though the Botanical Club was not officially a subdivision of the American Association its existence was occasionally recognized by that body. In 1888 abstracts of papers presented before the Club were printed in the Proceedings of the Association (2, vol. 37, p. 396) and in 1892 its activities were listed in the printed program. On several occasions the Club took action of considerable significance. In August 1892, at Rochester, N. Y., the Rochester Motions were adopted. They constitute the first rules of botanical nomenclature framed by a national group of American botanists. By their terms the Paris code of 1867 was accepted except where it conflicts with certain specified points. The law of priority was proposed as the "fundamental principle of botanical nomenclature," and the starting point was designated as the first edition of the *Species Plantarum* of Linnaeus of 1753. L. M. Underwood, serving as the delegate of the Botanical Club,

² At the Atlantic City meeting the Council of the Botanical Society of America voted to deposit these volumes permanently in the library of The New York Botanical Garden with the restriction that they be not loaned.

presented these motions before the International Botanical Congress at Genoa in September that year in connection with the quater-centenary celebration of the discovery of America. The

REGISTER.

August 1885

| NAME | RESIDENCE | PRESENT ADDRESS |
|------------------------|----------------------|-----------------------------------------------------|
| Charles E. Peck | Lincoln, Nebraska | Conn. State & Heron. |
| L. M. Pringle | Columbia, Mo. | 25 Thompson St. |
| N. Burritt | Champaign Ill. | 28 Division St. ^{25 no University annu} |
| Edwin Thurnmont | Genoa, W. V. | Genoa, W. V. |
| John M. Coulter | Grandfordville, Ind. | Chap. Bach S. Main St. |
| Byron D. Halsted | Ames Iowa | 30 Jefferson St. |
| C. R. Barnea | Lafayette, Ind. | Philip Bach S. Main St. |
| Lucien M. Underwood | Syracuse N. Y. | 74 S. Main St. |
| J. C. Arthur | Genoa, N. Y. | W. Bach, Main St. |
| May A. C. Swinson | Cambridge Mass | Mrs. Backus, Suffolk |
| Winifred L. T. Wolcott | Braintree Mass | Mrs. Backus |
| Chas. P. Peck | Boston, Mass | Mass. Col. Phar. |
| A. H. Worthington | Springfield Ill. | No 528 Division ^{13.5 Union, and} |
| W. L. Peck | Rockford Ill. | Ill. |
| J. J. Davis | Racine Wis. | 22 Thompson St. Ill. |
| Wm. H. Hale | Albany N. Y. | Franklin House |
| E. W. S. Holmes | Decorah Ia | 1012 State St. n. - 12 - 1885 |

FIG. 3. Upper portion of a page of the Register of the Botanical Club of the American Association.

motions and others submitted at Genoa initiated the revision of the Laws of DeCandolle which was completed at Vienna thirteen years later to give us the International Code. At the Washington meeting of the Club in 1903 a nomenclature commission was

appointed by the Club which drafted the set of rules which soon afterwards were adopted as the basis for a revision which became the American Code of Nomenclature (4, vol. 31, p. 249). In 1893 a committee of the Club prepared a check list of great usefulness which was published as volume 5 of the Memoirs of the Torrey Botanical Club with the title "List of Pteridiophyta and Spermatophyta Growing Without Cultivation in Northeastern North America." The Club had the distinction of being our first national botanical organization. Mycological papers appeared on its programs in increasing number yearly, but no effort was ever made to segregate them in a special program or to form a mycological section of the Club.

SECTION G

Section F of the American Association, established for biology in 1882, embraced both botany and zoölogy for eleven years. In 1893 (2, vol. 42, pp. 236-264) it became exclusively zoölogical, when the new Section G was formed for botany. The change in organization was effected at the Madison meeting held in August of that year. This meeting was most outstanding for botanists in that it was also the occasion for the holding of the Madison Botanical Congress and saw the origin of the Botanical Society of America.

The World's Columbian Exposition, commonly called the Chicago World's Fair, was held during the summer of 1893. Extensive botanical exhibits had been set up in the Horticultural Building and in several of the State buildings, and American botanists hoped that many foreign botanists would attend. The proximity of Madison to Chicago led to the plan to hold a Botanical Congress that summer in Madison in conjunction with the meeting of the American Association with the thought that it would attract foreign botanists in sufficient numbers to give it an international character. Actually few foreign botanists attended, and the meeting was finally designated not as an International Botanical Congress, but merely as the Madison Botanical Congress (6, vol. 18, pp. 350, 357, vol. 19, p. 386).

Section G, entering its first year of existence at Madison that summer, had as its first chairman Charles E. Bessey. In introducing his address, which dealt with Evolution and Classification,

he expressed deep satisfaction that for the first time in the history of the Association the botanists were met officially as a separate group (2, vol. 42, p. 237). Today the section has endured 43 years. It now serves chiefly as the official unit of the Association about which the various specialized botanical societies cluster, and through which their affiliation with the mother organization is accomplished. The program of Section G itself has been reduced to the minimum, and consists of the annual joint program with the botanical societies with which you are all familiar.

The Association, from its origin in 1848 until 1902, held all of its annual meetings in the summer. The practice of meeting at midwinter instead began with the 52nd meeting at Washington in December 1902, and has persisted to the present. Because the pleasant and profitable features of the summer excursions were missed an additional summer meeting was held at Ithaca, N. Y., in 1906. Since then the practice of holding two annual meetings, one during the Christmas holidays and one at midsummer, has been followed. The present meeting is the 99th. Next summer at Denver, a special program will commemorate the holding of the 100th meeting. The Association is now in its 89th year. During its life only seven botanists have served as its president. They were John Torrey (1855), Asa Gray (1871), G. Lincoln Goodale (1890), William G. Farlow (1904), Charles E. Bessey (1911), John M. Coulter (1918), and Liberty Hyde Bailey (1926). Only one of these, Doctor Farlow, may be listed as a mycologist.

BOTANICAL SOCIETY OF AMERICA

The Madison meeting of August 1893, at which Section G was established, also saw the birth of our first national botanical society, the Botanical Society of America (6, vol. 18, pp. 347, 348). For some years American botanists had wished to form such a society, but opinions had differed as to the feasibility of the attempt and as to the type of organization desired (4, vol. 19, p. 294; 6, vol. 17, p. 289). At Madison the Society came into being through formal action of the older Botanical Club of the American Association (4, vol. 21, p. 411; 6, vol. 19, p. 388; 7, Nos. 1, 2, 3, 11, 12, 13, 16, 19, 20). The Club elected ten men, admittedly prominent and active in the field, and instructed them to meet

and select fifteen others. It was the intent that the twenty-five individuals thus chosen should constitute the charter membership (4, vol. 20, p. 373; 6, vol. 18, p. 368). Actually, five of those selected declined membership. The names of the twenty who accepted follow:

| | |
|--------------------------|----------------------|
| Joseph C. Arthur | Byron D. Halsted |
| George F. Atkinson | Arthur Hollick |
| Liberty Hyde Bailey | Conway MacMillan |
| Charles R. Barnes | Benjamin L. Robinson |
| Charles E. Bessey | Charles S. Sargent |
| Nathaniel Lord Britton | John Donnell Smith |
| Elizabeth G. Britton | Roland Thaxter |
| John M. Coulter | William Trelease |
| Frederick Vernon Coville | Lucian M. Underwood |
| Edward L. Greene | William P. Wilson |

The founders of the Society felt that membership should be restricted to those who had published outstanding work and were actively engaged in botanical investigation. The society from the beginning was thus somewhat honorary in nature, and for years it admitted to membership only the older and better known botanists. Meanwhile, the Botanical Club continued its own existence, and was regarded as the more inclusive and democratic group. At the meetings of the American Association in the nineties formal more or less competing programs were held by the Botanical Club, Section G, and the newly formed Botanical Society.

Organization of the Botanical Society of America was completed at the Brooklyn meeting of the Association in August, 1894 (8), and its first annual meeting was held at Springfield, Mass., the following summer. A brief historical sketch of the society, with emphasis on its origin and early activities, is given by Atkinson in Publication 11 of the Society. At the end of five years the membership had increased to thirty-three. A definite effort was made to keep the group small and distinguished. Annual dues were twenty-five dollars. Newly elected members were given the status of associate, and were denied the privileges of voting and

holding office. Two of the charter members, Liberty Hyde Bailey and Roland Thaxter, tendered their resignations in 1898 after a brief four years of membership. Well known mycologists admitted during the early years of the Society were E. A. Burt, R. A. Harper, Charles Peck, W. T. Swingle, F. E. Clements, and Hermann von Schrenk. No attempt was made to publish a society journal.

In 1898, five years after the Botanical Society of America came into existence, another competing national botanical society, which took the name of Society of Plant Morphology and Physiology, was established. It held its meetings independent of the American Association. Its first president, W. G. Farlow, had declined charter membership in the Botanical Society of America. Its membership was somewhat larger than that of the Botanical Society and less effort was made to maintain exclusiveness. A number of prominent botanists were affiliated with both societies (7, No. 20, p. 45).

It may be of interest to mention in passing that the Bulletin of the Torrey Botanical Club, the first number of which appeared in January, 1870, was 23 years old when the Botanical Society of America was born (4, vol. 1, No. 1, 1870). The Botanical Gazette was almost as old, dating from 1875 when John Coulter began its publication privately at Hanover, Indiana, under the name Botanical Bulletin (5, vol. 1, No. 1, 1875).

AMERICAN MYCOLOGICAL SOCIETY

Our first national mycological society, the American Mycological Society, was organized December 26, 1903, at the second St. Louis meeting of the American Association (9, vol. 10, p. 46). Preliminary arrangements had been made by a committee of three, consisting of F. E. Clements, F. S. Earle, and C. L. Shear, appointed at an informal gathering of mycologists at the preceding Washington meeting in 1902. Roland Thaxter was elected president, F. S. Earle vice-president, and F. E. Clements secretary-treasurer. A report of this first meeting of the Society with a list of the papers read was published in the Journal of Mycology in 1904. The twenty-seven members of the society (7, No. 45) were:

Joseph Charles Arthur
George F. Atkinson
Howard J. Banker
Thomas J. Burrill
Edward A. Burt
Mark A. Carleton
Frederic E. Clements
George P. Clinton
Clara E. Cummings
Benjamin M. Duggar
Elias J. Durand
Franklin S. Earle
William Gilson Farlow
Bruce Fink

Edward M. Freeman
David Griffiths
George G. Hedgcock
Edward W. D. Holway
William A. Kellerman
Thomas H. Macbride
Andrew P. Morgan
William A. Murrill
Charles H. Peck
Percy L. Ricker
Cornelius L. Shear
Roland Thaxter
Samuel M. Tracy

Doctor Shear, who served as a member of the organizing committee, has explained to me the reasons for the formation of the new society. The younger mycologists, barred by rigid requirements from membership in the Botanical Society of America, felt that there was little or no place for them except in Section G. The situation is clearly appreciated if reference is made to the membership lists of the Botanical Society where prominent mycologists had to be content with the grade of associate. However, no sooner was the Mycological Society in existence than a number of botanists in the three societies (the Botanical Society of America, the Society of Plant Morphology and Physiology, and the American Mycological Society) expressed a growing conviction that the interests of botanical science as a whole would be more effectively advanced by a single organization. Thereupon a joint reorganization committee was formed with representation from the three societies. The mycologists at their first meeting had anticipated this move and had named a committee on "affiliation with other societies," consisting of C. L. Shear, G. F. Atkinson, and T. J. Burrill. The task of reorganization of the botanists and the preparation of a constitution acceptable to all members proved difficult and negotiations were carried on over a period of months before success was attained.

Meanwhile in December, 1904, the American Mycological Society held its second annual meeting at Philadelphia, elected Charles

H. Peck as President (FIG. 4), re-named F. S. Earle Vice-President, and made C. L. Shear, Secretary-Treasurer. A report of the meeting with a list of the papers presented is given in *Science* (10, vol. 21, p. 748). The third and last meeting of the Society was held in New Orleans in January 1906. In the absence of President Peck, Vice-President Earle presided (6, vol. 41, p. 160; 9, vol. 12, p. 85; 10, vol. 23, p. 186).

At New Orleans the report of the committee on reorganization of the botanists was accepted by the Society and a new constitution which had been prepared was adopted. By this action the three organizations were united under the name Botanical Society of America. The first president of the Society following this federation was George F. Atkinson. He had held membership in all of the three uniting groups. Today the reorganized Botanical Society of America has existed twenty years. A complete list of its past officers is printed annually in its Yearbook. Its membership, constituting that of the three older societies, totaled at the time of federation in 1906 only 119 botanists. Their names are listed in Publication 28 of the Society, their previous affiliations being indicated. There was little increase in membership of the new society in the years immediately following. The distinction between full membership and associate membership was maintained, and as late as 1909 we find (7, No. 39) the resolution adopted that "the Council may at any regular meeting of the Society recommend not more than five associate members for election to membership." No effort was made to broaden the scope of the Society, the applied branches of botany being essentially ignored. It is not surprising, therefore, that, in the same year that this resolution was adopted, the American Phytopathological Society was organized (10, vol. 31, p. 746). It began its outstandingly successful life with a charter membership of 130, and a pronouncedly democratic character. The Society was founded at Baltimore in 1908. Its first annual meeting was held the next winter in affiliation with the American Association, at the Harvard Medical School in Boston. Fifty members were in attendance, the first President, L. R. Jones, being in the chair. The membership fee, fixed at one dollar, was not increased until

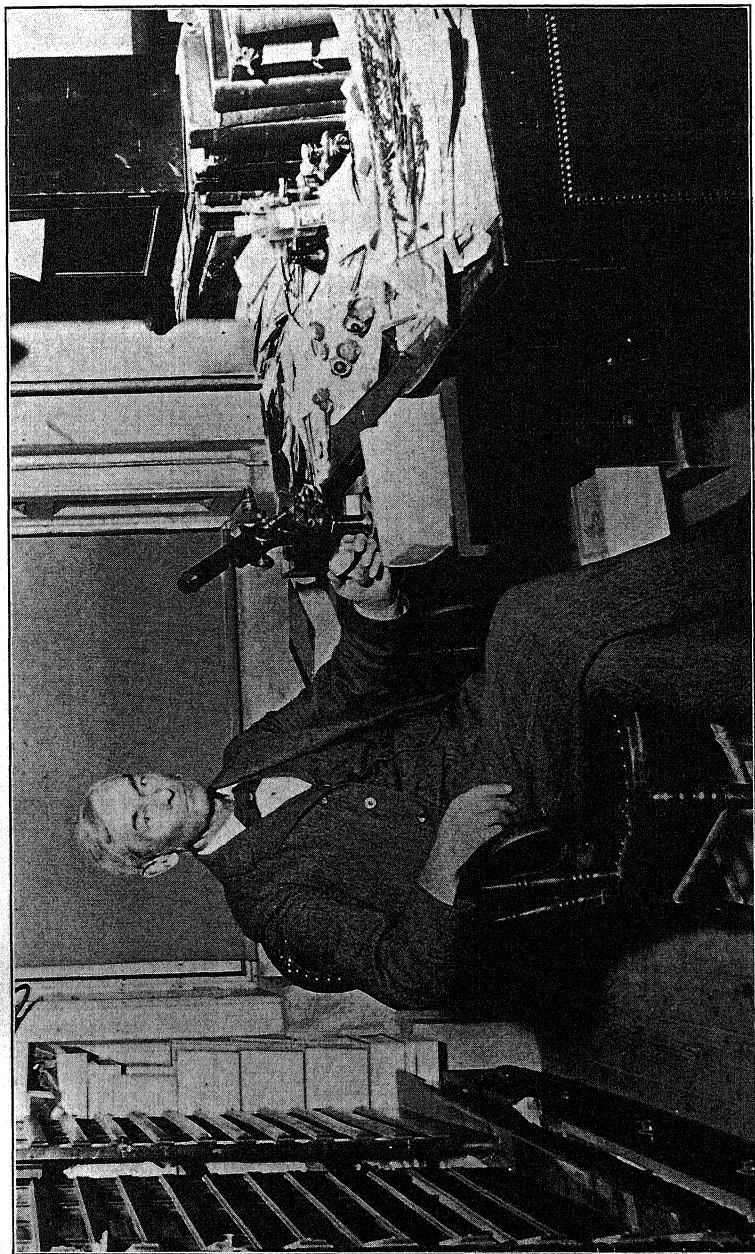


FIG. 4. Charles H. Peck in his office at the State House in Albany, N. Y. Photograph was taken in about 1904, the year of his election as the second President of the American Mycological Society. A photograph of Roland Thaxter, first President of the Society, is omitted because none is available showing him at that period of his life.

the journal, *Phytopathology*, was established two years later in February, 1911. Last Christmas at St. Louis the 25th birthday of the journal was appropriately celebrated at the *Phytopathologists' Dinner*. The membership of the Society has now reached a total in excess of 900.

The successful establishment of *Phytopathology* served to emphasize the need of the Botanical Society of America for its own official organ of publication. The demand that a journal be established grew, bringing with it the practical necessity for an enlarged membership. The reactionary element in the Society was finally over-ruled (8) and in January, 1913, after prolonged discussion, the constitution was so broadly emended that practically any individual actively engaged in botanical work might become a member. At the following meeting (10, vol. 39, pp. 253), 125 new members were admitted, and a contract was drawn up between the Society and the Brooklyn Botanic Garden which resulted in the establishment of the *American Journal of Botany* (11, vol. 3, pp. 74-76). Its first number appeared in January, 1914. Membership in the Society increased very rapidly, 87 new names being added in 1914, and 146 in 1915. The restricted total membership of 137 in 1909 has in a quarter of a century grown to approximately 1200. Nevertheless, the old point of view died hard, and even as late as 1914 a motion was drafted looking toward the establishment of an "honor grade" of membership to set the elect aside from the crowd. The more liberal viewpoint has prevailed and in 1918 the secretary of the Society in an appeal for increased membership says: "With growth the Society has assumed larger and wider responsibilities, well known to its members, until at the present time it is not alone the privilege, but distinctly the duty of every American botanist to share these responsibilities to our science by assuming the obligations of membership in the Society."

Four years after the establishment of the *American Journal of Botany* the first number of *Botanical Abstracts* appeared in September, 1918. In December, 1926, that journal was replaced by *Biological Abstracts*. The pages of these publications reveal to a startling degree the rapidity of the growth of botanical science in this country and in the world.

MYCOLOGICAL SECTION OF THE BOTANICAL SOCIETY

Increase in membership of the Botanical Society embracing many special interests soon led to the demand for the formation of sections. So many papers were submitted for presentation that subdivision of the membership and simultaneous programs became imperative necessities. In 1916 a Physiological Section was established, in 1917 a Systematic Section, and in 1919 a Mycological Section. Prior to 1919 papers on the fungi had been given largely

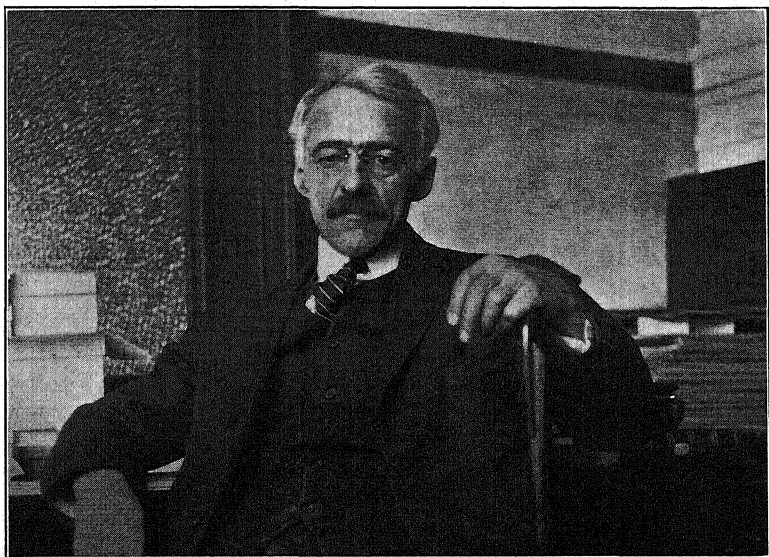


FIG. 5. Calvin H. Kauffman in his herbarium at the University of Michigan. Photograph taken by the author in 1921 the year following that in which he served as the first Chairman of the Mycological Section of the Botanical Society of America.

in a joint session held by the Botanical Society with the American Phytopathological Society.

A petition addressed to the Council of the Society and signed by twenty-five members interested in mycology gained permission to organize the Mycological Section (7, No. 75). Organization was effected at St. Louis in 1919, the first program of the Section being given at Chicago in 1920, with C. H. Kauffman (FIG. 5) acting as Chairman (7, No. 76, p. 9). The establishment of the

section proved a great stimulus to American mycologists, and resulted in the presentation of an increasing number of mycological papers. The section existed twelve years. Dates and places of meeting and names of officers are given in the accompanying table (7, No. 100, pp. 11-13, No. 106, p. 11).

| Date | Place | Chairman | Secretary |
|------|--------------|---------------------|------------------|
| 1920 | Chicago | Calvin H. Kauffman | |
| 1921 | Toronto | Arthur H. R. Buller | |
| 1922 | Cambridge | Cornelius L. Shear | |
| 1923 | Cincinnati | Wm. H. Weston, Jr. | |
| 1924 | Washington | Herbert S. Jackson | |
| 1925 | Kansas City | Edward M. Gilbert | Leva B. Walker |
| 1926 | Philadelphia | Frank L. Stevens | " " " |
| 1927 | Nashville | Wm. C. Coker | Carroll W. Dodge |
| 1928 | New York | Lee O. Overholts | " " " |
| 1929 | Des Moines | Carroll W. Dodge | George W. Martin |
| 1930 | Cleveland | Frank D. Kern | Alfred H. Povah |
| 1931 | New Orleans | Fred J. Seaver | Leon H. Leonian |

At the annual meetings of the Section, officers were chosen for the succeeding year, the recommendations of a nominating committee usually being adopted unanimously. Ballot of the entire membership by mail was never attempted. Membership in the Section was itself of a somewhat indefinite category, all members of the Botanical Society with an expressed interest in fungi being listed as members of the Section. The membership grew from 100 in 1920 to 202 in 1930. In 1921 at the Toronto meeting the first joint session with the American Phytopathological Society was held. The joint session held in Cleveland in 1930 was the occasion of the presentation of the outstanding deBary memorial program.

MYCOLOGICAL SOCIETY OF AMERICA

The need for a mycological journal which would be representative of the broad interests of the members of the Mycological Section and which could be designated as its official organ finally led to discussion of the desirability of the transformation of the Section into a separate Mycological Society. Practical problems having to do with the financing of such a journal argued against the feasibility of its publication by the Section itself. Moreover, for other reasons the proposed establishment of a new Society was

attractive to many students. The journal *Mycologia*, founded in 1909 at the New York Botanical Garden in continuation of the *Journal of Mycology*, had come to be regarded as the national mycological publication. Interest in its enlargement and improvement and the desire to avoid the duplication of expense and effort which would result from the establishment of a new journal led to consideration of the possibility of adoption of *Mycologia* as the official organ of the proposed Society. The editor, F. J. Seaver, and Director E. D. Merrill of the New York Botanical Garden were approached and found to be receptive to the idea. Though *Mycologia* was in a sound financial condition it did not have the support of the entire body of American mycologists. Careful consideration indicated that all parties would be benefited by the adoption of the journal as the Society organ, and that the science of mycology in America would be served better by the enlargement and improvement of the journal already in existence than by the establishment of another. With this end in mind the following questionnaire was prepared and sent out by H. H. Whetzel, July 20, 1931, to all members of the Mycological Section:

"Discussion with workers in several institutions in the United States and Canada seems to indicate a wide-spread feeling among students of fungi that the interests of mycology can be promoted to better advantage in America through the organization of an independent mycological society to take the place of the Mycological Section of the Botanical Society of America and to be affiliated with the American Association for the Advancement of Science as are the other organizations, the American Phytopathological Society, the American Society of Plant Physiologists, etc. As a member of the Mycological Section we would like to know your feeling in the matter. Are you in favor of the formation of such a society?"

Replies to this questionnaire were received from 116 individuals. Of these, 91 voted in the affirmative and 25 in the negative. Nearly four out of five favored the proposal. Moreover, analysis of the ballots revealed that a goodly percentage of the negative votes had come from students of botany whose interests were not outstandingly mycological. The affirmative vote was enthusiastic and convincing. The list of those voting "yes" included most of

the active mycologists and practically all of the distinguished names identified with the science on this continent. It was the desire of all that dissension be avoided, and the unanimous conviction that the Mycological Section should disappear at the birth of the new Society. The recent unfortunate experience of the plant physiologists was in the minds of all, and the need for an overwhelming majority in favor of the establishment of the Society and the adoption of *Mycologia* was recognized. Meanwhile, the editor, F. J. Seaver, had sent a similar questionnaire to the approximately 150 personal subscribers to *Mycologia*, and had received practically unanimous approval of the plan. The 300 institutional subscribers to the journal were not approached.

The following December Professor Whetzel presented the result of the vote before the Mycological Section at the New Orleans meeting, and moved the formation of the new Society. Having been active in the development of the American Phytopathological Society in its early years, he entered enthusiastically on the new venture of helping found the Mycological Society of America. He, more than any other, had urged its formation, and to him is due the major credit for having taken the initial moves which led to its establishment at New Orleans. Doctor Seaver, numbered among those who looked with favor on the formation of the Society and on the adoption of *Mycologia* as its official organ, was that year Chairman of the Mycological Section. The Society came into being by official action of the Section, and though several negative voices were heard the final vote was essentially unanimous. An organizing committee of five members was then named, Wm. H. Weston, Jr., its chairman being designated as the first president of the Society, Herbert S. Jackson, Neil Stevens, and C. R. Orton being named as councilors, and your speaker being selected as secretary-treasurer (12, vol. 24, p. 515). It is only fair to record that only one of these five men was present at the New Orleans meeting, that they were nominated without their knowledge, and that none of them had been outstandingly an advocate of the formation of the Society. This committee, named to serve only for 1932, gave consideration during the year to the problems confronting the new organization, and sent out an invitation to charter membership which gained a most favorable re-

sponse. A note was published in *Science* inviting all persons interested in the fungi to affiliate with the Society, and a type-written invitation was sent to more than one thousand individuals. All personal subscribers to *Mycologia*, all members of the Botanical Society of America listed as having a mycological interest, and all members of the American and Canadian Phytopathological Societies were thus given the privilege of being listed as charter members.

Although a relatively small number of individuals, assembled at New Orleans, had voted the Society into existence, the charter membership thus compiled embraces 279 names (12, vol. 26, p. 108). Tabulation of these names reveals that 149 individuals had been personal subscribers to *Mycologia*, 139 were members of the Botanical Society of America, 156 belonged to the American Phytopathological Society, 8 were affiliated only with the Canadian Phytopathological Society, while 44 names were new. The formation of the Mycological Society had been opposed by various members of the Botanical Society on the assumption that the older organization would be weakened by numerous resignations. It now appears that this fear was largely unfounded. A careful check of membership lists has recently revealed that of the 139 members of the Botanical Society who joined the Mycological Society in 1932 only 19 have been lost to the older organization. Only 7 of the 156 who came to us from the American Phytopathological Society have resigned from that society.

At the approach of the Atlantic City meeting of December, 1932, the organizing committee of the Mycological Society prepared a program, all charter members having been asked to take part. A business session was scheduled, and announcement was made of our intention to complete the organization of the Society and move the adoption of *Mycologia*. The committee met, December 27, and arranged materials for submission to the Society at its open business session the following day. A constitution and by-laws prepared by President Weston were edited and approved. Officers were nominated for 1933, and an editorial board for *Mycologia* was selected which named F. J. Seaver as its editor-in-chief (12, vol. 25, pp. 66, 152). The session the following day was outstandingly successful. Under the skillful and diplomatic

handling of President Weston (12, vol. 25, pp. 69-89, vol. 26, pp. 113-114), the meeting accomplished all necessary business without friction or misunderstanding, and the Society completed its organization with unanimous votes on practically all motions brought before it. There was a feeling akin to elation that the specter of a split in our ranks had failed utterly to materialize. *Mycologia* became the official organ of the Society on terms which had been arranged tentatively with the New York Botanical Garden. The meeting was well attended, forty mycological papers, representing a wide and varied interest, being presented on the program. The practice of holding joint sessions with Section G and with the American Phytopathological Society was begun.

The second annual meeting of our Society took place the following December in Boston with President C. L. Shear in the chair (12, vol. 26, p. 197). The third was held in December, 1934, at Pittsburgh, President H. S. Jackson presiding (12, vol. 27, p. 225). The fourth meeting last winter at St. Louis (12, vol. 28, p. 197) and the pleasing address of President B. O. Dodge are fresh in the minds of many of us. Summer forays have been held, in 1933 at the Highlands Museum and Biological Laboratory at Highlands, North Carolina (12, vol. 25, pp. 233, 330, 550, vol. 26, p. 195), in 1934 at the summer camp of Professor F. C. Stewart on Seventh Lake near Inlet, New York, in the southern Adirondack Mountains (12, vol. 26, pp. 277, 377, vol. 27, p. 323), in 1935 at Ithaca, New York, with headquarters in the Laboratories of the Department of Plant Pathology of Cornell University (12, vol. 27, p. 327, vol. 28, p. 98), and the past summer at Mountain Lake, Virginia, at the summer camp of the University of Virginia (12, vol. 28, p. 297). The present Atlantic City meeting marks the fourth anniversary of our first meeting here in 1932 and the fifth of the establishment of the Society at New Orleans. Our membership has now reached a figure slightly above 350. The Society is in a sound condition financially and has every reason to expect a long and useful life. With an increasing membership, with an enlarging and improving journal, with a fine spirit of friendship and coöperation existing throughout our ranks we face the future with optimism. It is our expectation that the Mycological Society of America will increase in size and usefulness, and

our hope that an enlarging *Mycologia* will publish material of such uniform excellence that it will stand preëminent among the mycological journals of the world.

CORNELL UNIVERSITY,
ITHACA, NEW YORK

LITERATURE CITED

1. Association of American Geologists and Naturalists, Transactions 1840-1842, Boston. Gould, Kendall, and Lincoln 1843.
2. American Association for the Advancement of Science, Proceedings.
3. American Naturalist.
4. Torrey Botanical Club, Bulletin.
5. Botanical Bulletin.
6. Botanical Gazette.
7. Botanical Society of America, Publications.
8. Botanical Society of America, Minutes of the Secretary (unpublished).
9. Journal of Mycology.
10. Science, n.s.
11. Brooklyn Botanic Garden, Record.
12. *Mycologia*.
13. Botanical Club of the American Association, Proceedings (unpublished).
14. Mycological Society of America, Minutes of the Secretary-Treasurer (unpublished).

NOTES ON CHINESE CERCOSPORAE

CHARLES CHUPP AND DAVID H. LINDER¹

(WITH 1 FIGURE)

During the course of a coöperative undertaking of the University of Nanking and the Farlow Herbarium of Harvard, the latter institution has received a number of parasitic fungi. Among these are quite a few representatives of the genus *Cercospora*, all of which were collected by Mr. S. Y. Cheo whose numbers are cited below.

These collections are of interest since a large proportion of them represent the *Passalora* or *Cladosporium* type of fructification in which the fungi at first form no definite spots, but rather produce effuse velvety layers over parts of the leaf surface. In certain of the species, the conidiophores arise in two manners: from the repent vegetative mycelium as erect or ascending side-branches, or else either singly or in clusters from the stomata of the host. However, although the former type seems to be characterized by more elongate conidiophores, nevertheless they essentially are morphologically identical, as is also true of the conidia.

In the list which follows, the species are arranged alphabetically and not according to any concept of phylogenetic relationships of the various hosts.

1. CERCOSPORA AGERATOIDES Ellis & Ev.

On *Eupatorium* sp., Lao Hu Tung, Ch'ing Yang Hsien, Anhwei Prov., Oct. 12, 1932, No. 1199; Shiang Lu Shib, Ch'ing Yang Hsien, Anhwei Prov., Oct. 9, 1932, No. 1156; Ta Tseh Shan, Yung Hsien, Kwangsi Prov., Sept. 1, 1933, No. 2672.

2. CERCOSPORA ARALIAE P. Henn.

On *Aralia* spp., Liang Feng Yah, Tsunyi Hsien, Kweichow Prov., on *A. dasyphylla*, July 18, 1931, No. 93; Fan Ching Shan,

¹ Contribution from the Department of Plant Pathology, Cornell University, and from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University, No. 147.

Chiang K'ou Hsien, Kweichow Prov., on *Aralia dasyphylla*, Sept. 6, 1931, No. 367; Hsiu Feng Ssu, Hsing Tsu Hsien, Kiangsi Prov., Sept. 16, 1932, No. 944; Kuan Yin Tung, Ch'ing Yang Hsien, Anhwei Prov., Oct. 13, 1932, No. 1216; Ta Tseh Shan, Yung Hsien, Kwangsi Prov., Aug. 10, 1933, No. 2425 and Aug. 20, 1933, No. 2539.

3. *Cercospora Broussonetiae* sp. nov. (FIG. A)

Maculae primum indefinitae, fungus stratum amphigenum effusum, 2-4 mm. latum, atro-olivaceum formans, superne paucius; stromatis parenchymatis sphaericis atro-fuscis vel fere atris, 30-70 μ diametro, hyphas conidiferas dense fasciculatas gerentibus; conidiophoris conspicuiter septatis, nonnumquam ad septa constrictis, non geniculatis tamen curvatis vel flexuosis, raro ramosis, olivaceo-fuscis, 4-6 \times 50-150 μ ; conidiis cylindraceis vix obclavatis, olivaceo-brunneo vel fuligineo-brunneis, rectis vel nonnihil curvatis, ad bases obconicis truncatisque, ad apices rotundatis, 4-5.5 \times 40-90 μ , pluriseptatis, frequente arcte septatis.

Hab. in foliis *Broussonetiae* sp.

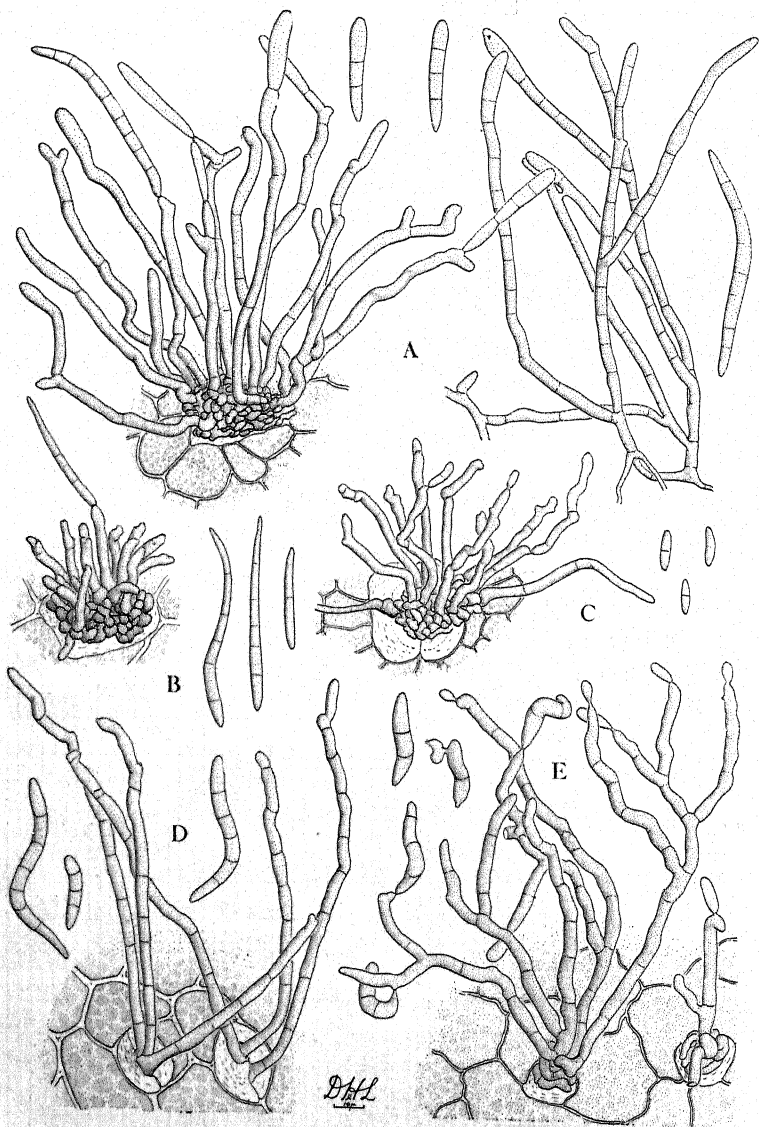
No definite leaf-spot, at least at first; fruiting in amphigenous, effuse, dark olivaceous layers, 2-4 mm. in extent, the colonies much more sparingly formed on the upper than the lower surface; the stromata dark brown to almost black, globular, 30-70 μ in diameter, giving rise to dense fascicles of conidiophores; conidiophores plainly septate, occasionally the septa are very close together (4 μ), sometimes constricted at the septa, not geniculate although sometimes bent and not uniform in width, rarely branched, olivaceous brown, 4-6 \times 50-150 μ , spore scars not conspicuous; conidia more nearly cylindrical than obclavate, olivaceous brown or fuliginous brown, plainly many-septate, the septa often very close together (2.5 μ), straight or only slightly curved, the base conical and truncate, the tip bluntly rounded, 4-5.5 \times 40-90 μ .

On leaves of *Broussonetia* sp., Ta Tseh Tsuen, Yung Hsien, Kwangsi Prov., Oct. 17, 1933, No. 2900, **Type**.

4. *Cercospora Cheonis* sp. nov. (FIG. C)

Maculae orbiculares, 1-5 (plerumque 2-3) mm. diametro marginibus prominente elevatis, primum atrae deinde caesiae vel alutaceae, denique maculae excidunt; stromatis hypophyllis, sphaericis vel hemisphaericis, atro-brunneis vel atris, 25-50 μ diametro, hyphas conidiferas dense fasciculatas gerentibus; conidiophoris fuligineo-brunneis, multiseptatis, leniter geniculatis, raro ramosis, 2-3.5 \times 40-100 μ ; conidiis cylindraceis, rectis vel raro subrectis, plerumque 1-septatis, fuliginea-oblivaceis, 3-4 \times 15-30 μ , extremis rotundatis.

Hab. in foliis *Ilicis* sp.



FIGS. A, *Cercospora Broussetiae*; B, *C. Vanierae*; C, *C. Cheonis*;
D, *C. cylindrata*; E, *C. Leguminum*.

Spots circular, 1-5 (mostly 2-3) mm. in diameter, with prominently raised line as border, the spots at first are apparently tar black but then turn tan to gray, later the leaf-spots may drop out leaving a shot-hole effect; stromata hypophyllous, globular, dark brown to almost black, $25-50\ \mu$ in diameter; the fascicles dense; the conidiophores $2-3.5 \times 40-100\ \mu$, fairly dark fuliginous brown, multiseptate, slightly geniculate, rarely branched and with spore scars seldom visible; conidia cylindrical, straight or nearly so, mostly 1-septate, fuliginous olivaceous, with bluntly rounded ends, $3-4 \times 15-30\ \mu$.

On leaves of *Ilex Wilsonii* Loes., Huang Yen Ssu, Hsing Tzu Hsien, Kiangsi Prov., Sept. 13, 1932, No. 922, **Type**.

5. *Cercospora cylindrata* sp. nov. (FIG. D)

Maculae indefinitae; fungus hypophyllus, stratum atro-olivaceum vel atrum coactatum formans; stromata absunt; conidiophoris (90)-150-290 \times 4.5-6.0 μ , non fasciculatis vel 1-5 ex stomatibus hospitis exsurgentibus, frequenter singillatim ab hyphis sterilibus ramosis, fuligineo-brunneis, 4-5 μ diametro, repentibus oriundis; conidiis fuligineo-brunneis, cylindraceis, curvatis vel spiraliter undulatis, ad apices rotundatis, ad bases obconicis, 4-6.5 \times 25-75 μ , 3-septatis, septis conspicuis.

Hab. in foliis *Dioscoreae* sp.

No definite leaf spots; fruiting in a dark olivaceous to almost perfectly black, felty layer on the lower surface of the leaf; conidiophores not in fascicles but consisting of branches arising from procumbent, septate, branched mycelial threads that are 4-5 μ in diameter, or else the fuliginous brown conidiophores, 4.5-6 \times (90)-150-290 μ , arise singly or in loose clusters of from 2-5; conidia distinctly cylindrical, fuliginous brown, variously curved or undulate, the apex bluntly rounded, the base sharply obconical, 4-6.5 \times 25-75 μ , the septa quite evident and 3-5 in number.

On leaves of *Dioscorea* sp., Yung Hsien, Ta Tseh Tsuen, Kwangsi Prov., Aug. 18, 1933, No. 2515, **Type**.

C. cylindrata resembles *C. alpiniae* in some respects, but the latter produces noticeably darker colored conidiophores and conidia, and the conidiophores are single, unbranched stalks. It differs from all other named species on the Iridales, Liliales, or Alismatales, in having wide, distinctly cylindrical conidia on procumbent branched threads.

6. *CERCOSPORA FERRUGINEA* Fuckel.

On *Artemisia* sp., Han Young Feng, Lu Shan, Kiangsi Prov., Sept. 24, 1931, No. 1053.

This species has previously been reported from Cina.

7. *CERCOSPORA ITEODAPHNES* Thüm.

On *Actinidia callosa* Lindl., vel rel., Ta Ho Yen, Chiang K'ou Hsien, Kweichow Prov., Sept. 21, 1931, No. 570.

This species was first described from Ceylon.

8. *Cercospora Leguminum* sp. nov. (FIG. E)

Maculae primum indefinitae deinde superficie supra brunescens dum in superficie infera fungus stratum densum, effusum, atro-olivaceum vel subnigrum efficit; stromata exilia vel absunt; conidiophoris non definite fasciculatis vel fasciculatis, procumbentibus vel erectis flexuosisque, ramosis, conspicuiter septatis, saepe ad septa constrictis, non geniculatis, curvis autem vel superne breve ramosis, olivaceo-brunneis, $4-6.5\ \mu$ diametro; conidiis rare rectis, plerumque curvatis, nonnihil undulatis vel uncinatis, cylindraceutis, ad bases elongato-obconicis, ad apices abrupte rotundatis, dilute olivaceo-brunneis, $4.5-7.5 \times 15-50\ \mu$, septis conspicuis, 1-4.

Hab. in foliis *Crotalariae*? (Leguminosae).

No definite leaf spot formed, at least at first, but later the upper part of the leaf turns brown while on the corresponding lower surface is formed a heavy, effuse, fruiting layer, dark olivaceous to almost black in color; stroma poorly developed or lacking; conidiophores not in definite fascicles, procumbent to erect, branched, plainly septate, sometimes constricted at the septa, frequently not uniform in diameter, not geniculate but may be bent in various ways or have short branches near the tip, olivaceous brown, $4-6.5\ \mu$ wide and of indeterminate length; conidia rarely straight, mostly irregularly curved, hook-shaped, S-shaped, and sometimes almost a complete circle, cylindrical, elongate-obconical at the base and bluntly rounded at the apex, $4.5-7.5 \times 15-50\ \mu$, pale olivaceous brown, mostly 1-4-septate, the septa conspicuous brown.

On leaves of *Crotalaria*? vel rel., Lo Ch'en, Kwangsi Prov., Oct. 1, 1933, No. 2873, Type.

9. *CERCOSPORA MELIAE* Ellis & Ev.

On *Melia* sp., Kuan Ying Chioo, Lu Shan, Kiangsi Prov., Sept. 25, 1932, No. 1064.

From a study of the type materials, it seems that *C. Meliae* Ellis & Ev. 1887, *C. leucosticta* Ellis & Ev. 1888, and *C. subsessilis* Sydow 1913, have similar white spots, brown stromata, mostly short conidiophores which bear obclavate subhyaline conidia with conical or subconical bases. *C. meliicola* Speg. has pale olivaceous stromata, fairly long conidiophores, and very narrow, thread-like, hyaline conidia of which the bases are truncate. *C. congoensis* Sydow is *Cladosporium*-like, does not produce stromata, and bears conidia that are 7-9 μ wide.

10. CERCOSPORA MIURAE Sydow.

On *Cynanchum* sp., Lao Hu Tung, Ch'ing Yang Hsien, Anhwei Prov., Oct. 12, 1932, No. 1198.

First described from Rebun Island.

11. CERCOSPORA PACHYDERMA Sydow.

On *Dioscorea* spp., Ta Ho Yen, Chiang K'ou Hsien, Kweichow Prov., Sept. 14, 1931, on *D. pentaphylla*, No. 479; Ta Tseh Shan, Yung Hsien, Kwangsi Prov., Aug. 5, 1933, No. 2346.

12. CERCOSPORA PERSONATA (Berk. & Curt.) Ellis.

On *Arachis*, Hsing Tsu Hsien, Lu Shan, Kiangsi Prov., Sept. 17, 1932, No. 958; Shiang Lu Shih, Ch'ing Yang Hsien, Anhwei Prov., Oct. 13, 1932, No. 1234; Ta Tseh Shan, Yung Hsien, Kwangsi Prov., Aug. 16, 1933, No. 2492.

13. CERCOSPORA POLYGONORUM Cooke.

On *Polygonum aviculare* L. vel rel., Ta Ho Yen, Chiang K'ou Hsien, Kweichow Prov., Oct. 7, 1931, No. 663.

This species, as *C. hydropiperis*, has been reported from many countries.

14. CERCOSPORA SNELLIANA Reichert.

On *Morus* sp., Syn.: *C. Mori* Mar. & Stey.

Liang Feng Yah, Tsunyi Hsien, Kweichow Prov., Aug. 2, 1931, No. 209.

This species was first described from Egypt, and later as *C. Mori* from the Belgian Congo.

15. *Cercospora Vanierae* sp. nov. (FIG. B)

Maculae primum indefinitae, fungus stratum hypophyllum effusum, olivaceum formans, interdum in superficie superfiore pustulas olivaceas, myceliorum apressorum, ramosorum conidia gerentium constatas, 0.5–2 mm. diametro formans, in superficie inferiore conidiophoris semi-fasciculatis in stromatibus, ramosis, conspicuiter septatis, interdum ad septa constrictis, dilute olivaceo-brunneis, nonnumquam geniculatis, $4-6 \times 50-110 \mu$; conidiis conspicuiter obclavatis, dilute olivaceis, rectis vel curvulis, ad apices acutis, ad bases longè obconicis truncatisque, $3.5-5.5 \times 50-100 \mu$, multiseptatis frequenterque 5μ separatim.

Hab. in foliis *Vanierae tricuspidatae* (Bur.) Merr.

No definite leaf spots, at least at first; fruiting in hypophyllous, effuse olivaceous layers, ranging in extent from 0.5 mm. to fairly large parts of the leaf surface; sometimes on the upper surface are small dark olivaceous pustules, 0.5–2 mm. in extent, composed of appressed, procumbent, branched threads on which the conidia are borne. On the lower leaf surface the conidiophores are in fascicles or semi-fascicles arising from stromata, branched, plainly septate, sometimes constricted at the septa, pale olivaceous brown, sometimes plainly geniculate, spore scars not present, $4-6 \times 50-110 \mu$; conidia plainly obclavate, pale olivaceous, straight to slightly curved, tip rounded acute to sub-acute, base long, obconically truncate, septa evident, many, and in some cases as close together as 5μ , $3.5-5.5 \times 50-100 \mu$.

On leaves of *Vaniera tricuspidata* (Bur.) Merr., Sze Nan Hsien, Kweichow Prov., Aug. 27, 1931, No. 338, **Type**.

Type specimens of the new species above described, have been deposited in the Farlow Herbarium, Harvard University, and in the Herbarium of the Department of Plant Pathology, Cornell University.

CORNELL UNIVERSITY
AND
HARVARD UNIVERSITY

EXPLANATION OF FIGURES

Fig. A. *Cercospora Broussonetiae*. The figure on the right shows the conidiophores arising from the repent vegetative mycelium. On the left, the conidiophores are shown arising from the stroma that is formed over the stoma of the host. In both figures are to be seen the rather characteristic swellings of the terminal cells of the conidiophores. **Fig. B.** *Cercospora Vanierae*. On the left is shown a dense fascicle of conidiophores which arise from the stroma, while on the right are three conidia that illustrate in part the variation in size and shape. **Fig. C.** *Cercospora*

Cheonis. Three conidia and the fascicle of conidiophores are here shown. The conidiophores are characterized by the subgeniculate apical cells and by occasional deep constrictions at the septa. Not infrequently, one or more of the conidiophores bend over and serve in much the same fashion as stolons. **Fig. D.** *Cercospora cylindrata*. The conidiophores are shown arising from the stoma of the host without the formation of any stromatic base. The three conidia illustrate the variation to be found in this species. **Fig. E.** *Cercospora Leguminum*. The branched, undulate conidiophores of this species arise from a poorly developed stromatic base that consists of a few coiled and interwoven hyphae. Not infrequently the conidia are not only spirally undulate, but may also be horse-shoe shaped, and occasionally the spores proliferate to form a secondary spore that is smaller and of a lighter color.

DIPODASCUS UNINUCLEATUS¹

ROSEMARY BIGGS²

(WITH 50 FIGURES)

The fungus to be described in the following pages was originally obtained in culture from a dead pupa of *Drosophila melanogaster*. The most remarkable character of the agar colonies is the production of multispored asci which bear a strong resemblance to those described for *Dipodascus albidus* Lag. A detailed study of the development of these structures has indicated that, although the organism is indeed closely related to that much discussed species, it presents a number of interesting differences.

The life history of *D. albidus* has been studied in detail by Lagerheim (8), Juel (7) and Dangeard (3). The species has always occupied a somewhat isolated position among the fungi. The coenocytic cell structure and the development of multispored asci following the fusion of two simple multinucleate gametangia have been thought to indicate affinities with the Phycomycetes. On the other hand a relationship with the Ascomycetes is suggested by the method of spore formation and the absence of a resting zygote. The apparently transitional nature of this fungus has led to the rather general opinion that it represents an intermediate link in the evolution of the Ascomycetes from the Phycomycetes (1, 2, 4, 5, 9, 10 and 11). It is on account of the theoretical significance assigned to *D. albidus* that the discovery of another species in this genus is of especial interest.

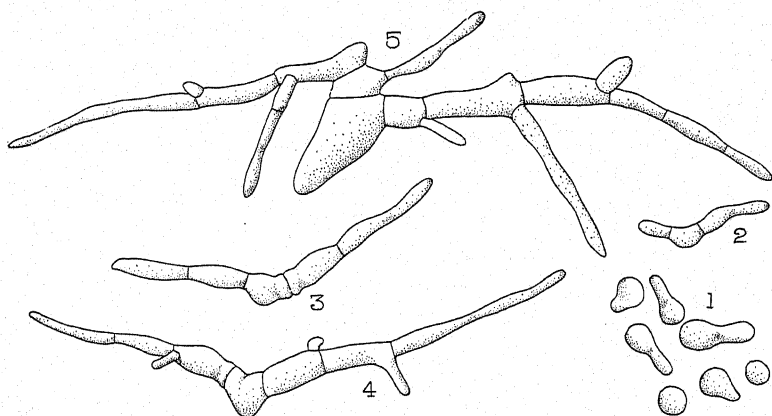
Dipodascus uninucleatus was grown on a number of media including a variety of liquid sugars, potato dextrose agar, a one per cent lactose agar and a one and two per cent malt extract agar. The latter medium was found to be the most satisfactory. The growth in liquid media was in general poor.

¹ Contributions from the Department of Botany, University of Toronto.

² This study has been made under the direction of Professor H. S. Jackson to whom I wish to express my appreciation for continued interest and helpful suggestions.

In addition to the original gross cultures a number of monospore cultures were obtained by pouring dilution plates from ascospores. These did not differ from the polysporous cultures and asci were developed in abundance indicating that the fungus is homothallic.

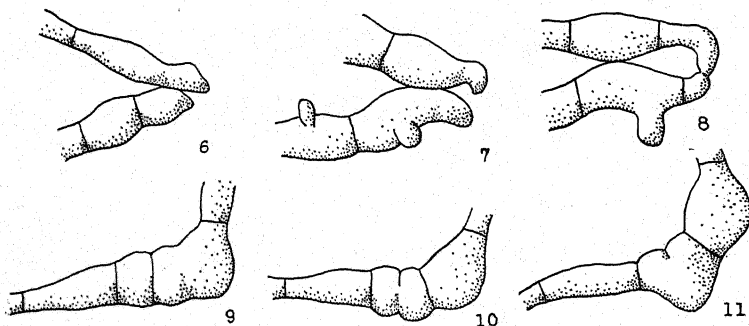
A study of the development of the organism was made by continuous observation of developing threads derived from germinating ascospores growing in a two per cent malt extract solution in van Tieghem cells. In such preparations the whole life cycle can be followed in a single filament from the germination of the spores to the maturation of the asci.



FIGS. 1-5. Stages in the germination of growth of the ascospores. 1, germinating spores from a thirty-six hour culture; 2-5, stages in the growth of a single filament; 2, after forty-eight hours; 3, after sixty-two hours; 4, after seventy-one hours; 5, after eighty-five hours. All figures $\times 710$.

During the first twenty-four to thirty-six hours after transfer to a hanging drop the minute ellipsoid spores, $0.6-1 \times 2-2.5 \mu$, swell considerably and assume a spherical form, $3-4 \mu$ in diameter. A short germ-tube is then put out from one side of the expanded spore (FIG. 1) and during the next two or three days a short filament of four or five cells is produced (FIG. 2, 3). At this stage ascus formation begins (FIG. 3-5). Vegetative growth continues and the hyphae become more or less extensively branched (FIG. 4, 5). This organism differs from *D. albidus* in the complete absence of asexual reproduction.

The first sign of ascus development is the formation of two small contiguous cells usually in the central region of the filament (FIG. 3, 9). Almost before these cells are fully delimited the septum between them begins to disappear and after about two hours fusion is complete (FIG. 9, 10). The two uniting cells do not invariably arise from the same filament but, especially in crowded culture, fusion may occasionally take place between terminal cells of different filaments (FIG. 6-8).



FIGS. 6-11. Stages in cell fusion. 6-8, consecutive stages in the fusion of terminal cells of different filaments; 6, after forty-eight hours growth; 7, after fifty hours growth; 8, after sixty-seven hours growth; 9-11, consecutive stages in the fusion of intercalary cells in the same filament; 9, after forty-eight hours growth; 10, after fifty hours growth; 11, after fifty-three hours growth. All figures $\times 1250$.

CYTOLOGICAL INVESTIGATIONS

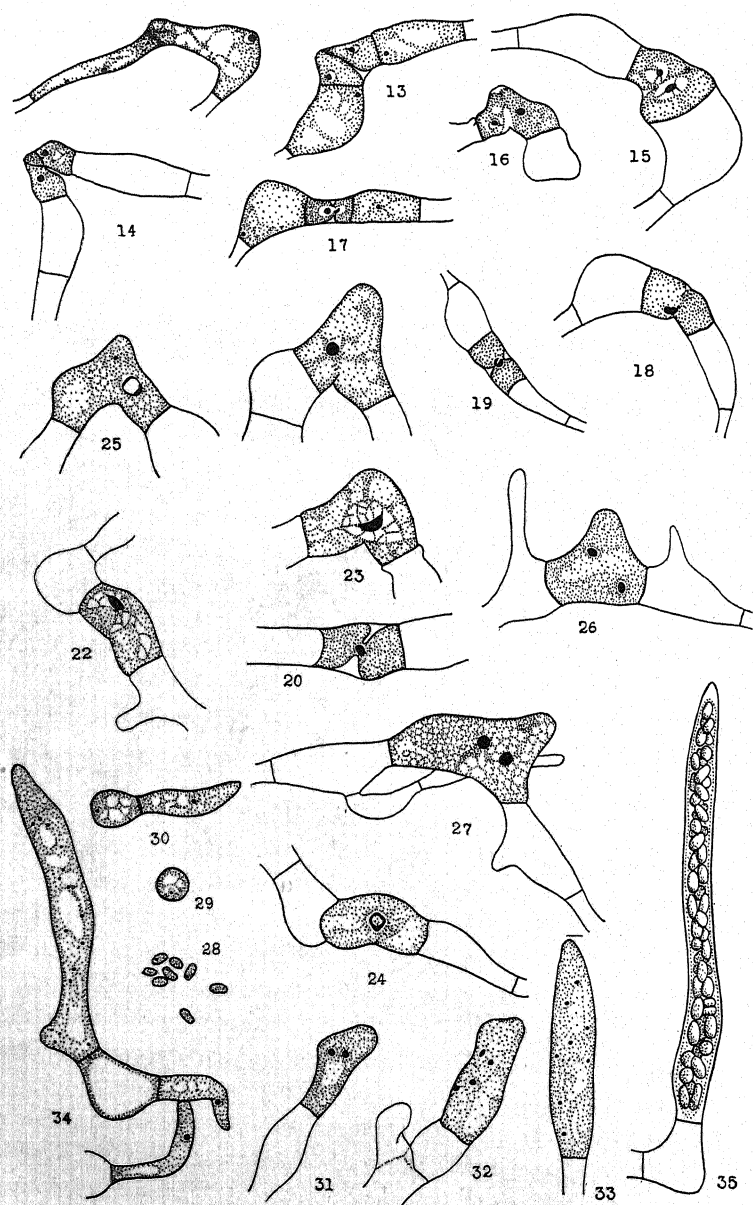
A cytological study of ascus development was made with germinating ascospores grown in van Tieghem cells. The cultures were watched until the required stage was reached when a drop of Bouin's fluid was added. The sporelings were attached to the cover glass by allowing the cultures to dry down in the fixing solution. The preparations were then thoroughly washed and stained by the iron alum haematoxylin method. It is recognized that this technique is by no means delicate, however it was unnecessary for the present purposes to study details of nuclear division and microtome sections proved unsatisfactory owing to the difficulty in obtaining whole asci in any one section.

The ascospores and all the cells of the hyphae are uninucleate. This is an important distinction from *Dipodascus albidus* in which

the vegetative cells are consistently multinucleate. In the formation of the copulating cells an accumulation of cytoplasm occurs on either side of a transverse septum, whereupon the nuclei in the adjoining cells divide and two minute cells are cut off (FIG. 12, 13). These cells are not always of exactly the same size (FIG. 15) nor are they invariably cut off at exactly the same time (FIG. 9). However no consistent differences such as would lead to the distinction between male and female gametangia could be recognized. The next stage in development is the dissolution of the dividing wall, this does not occur evenly over the whole surface but may begin at the centre (FIG. 15, 17, 19, 20) or towards one side (FIG. 16). Nuclear fusion usually occurs at an early stage in cell fusion and often takes place in the narrow passage joining the two cells (FIG. 19-20). The fusion nucleus enlarges and finally divides (FIG. 21-27). The further development of the ascus is very simple. The cell elongates considerably and a number of simultaneous nuclear divisions occur. The number and position of the nuclei can be traced with accuracy until the fifth division when thirty-two nuclei are present (FIG. 36-41). After this the nuclei become so small and so numerous that they cannot be counted with accuracy, it is however evident that several additional divisions occur before the spores are delimited. From the irregular arrangement of the nuclei during all stages of development it is apparent that no set orientation of the spindles occurs in the first three divisions as has been reported for *D. albidus* (3).

It is scarcely possible to study the details of the cytology of spore formation owing to the very minute size of the nuclei at this stage. The asci developed in van Tieghem cells never attain to more than half the maximum size of those developed on agar. On this account it was found most satisfactory to study the morphology of spore formation in crushed preparations of agar colonies.

An examination of nearly mature asci shows that the spores are often not formed simultaneously throughout the whole length of the ascus but are delimited progressively from the tip downwards. Mature spores may be present at the tip of an ascus in which the lower half is filled with undifferentiated protoplasm and free nuclei (FIG. 42). In early stages of delimitation the spores



FIGS. 12-35. 12-27, early stages in ascus formation; 12-17, formation and fusion of copulating cells; 18-20, stages in nuclear fusion; 21-25, enlargement and division of the fusion nucleus; 26-27, binucleate asci; 28-30, ascospores and stages in germination; 31-35, stages in parthenogenetic development of asci. All figures $\times 1550$.

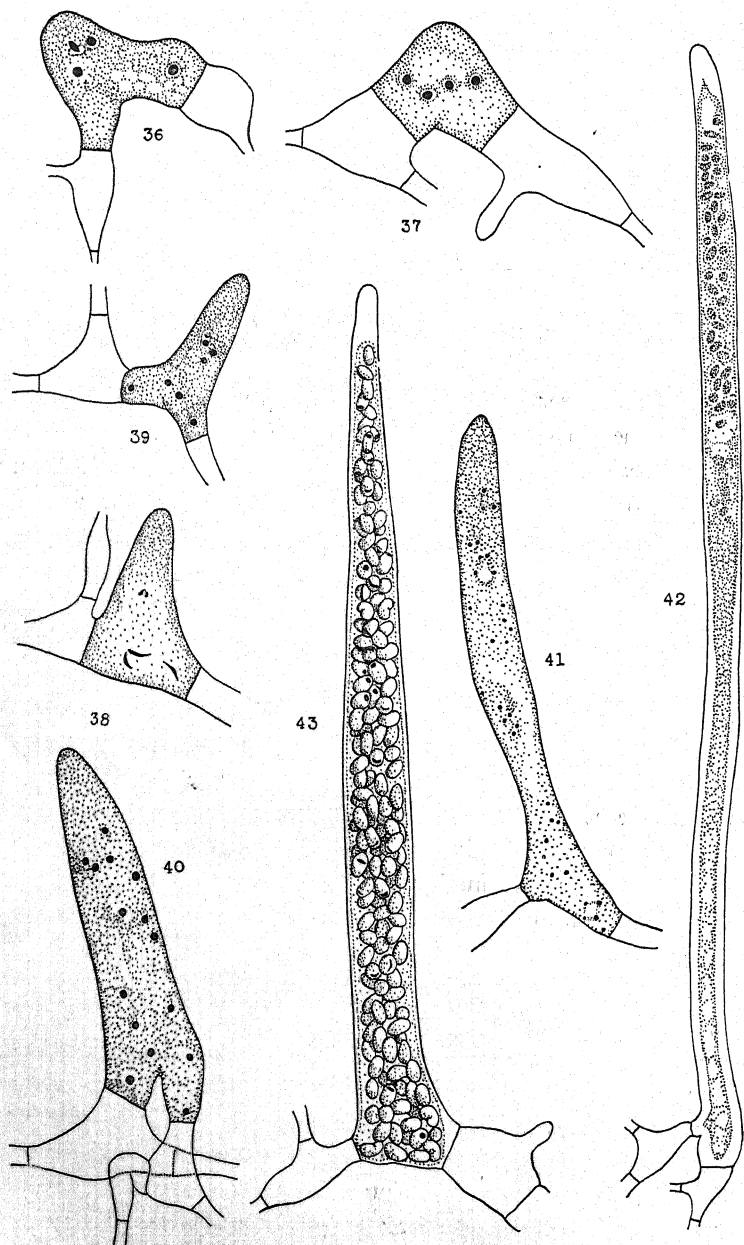
are seen to be embedded in epiplasm indicating their origin by free cell formation. This extraneous cytoplasm is absorbed during the maturation of the spores and finally no trace of it remains. There is some evidence from cytological preparations that the nuclei may be eccentrically placed in the young spores as was recorded by Dangeard (3) for *D. albidus* (FIG. 43).

The method of liberation of spores is of interest. Just before their formation, the ascus wall begins to swell. This swelling is limited at first to the extreme tip and to the basal region (FIG. 42). As development progresses the tip of the ascus gelatinizes leaving a free opening for the liberation of the spores. The swelling of the vertical wall continues progressively from the base towards the tip of the ascus forcing the spores out of the tip where they accumulate as a sticky ball. These finally roll down the sides of the protruding asci and develop into new threads.

From these observations the following general picture of the growth of the fungus may be obtained. The spores germinate, and develop into filaments of limited growth. Asci are formed and spores are liberated all in the course of four or five days. These spores in turn grow and produce asci. Thus successive generations pile up on the original colony all the hyphae of which meantime extend slowly by vegetative growth. The asci produced by later generations become progressively smaller and less abundant as the availability of the food decreases. Finally very few asci are produced and the colony changes very little in size and general appearance during long periods of time.

Two theoretically interesting variations on this general theme might be noted.

Occasionally asci may develop without a previous fusion of cells. This conclusion is indicated by the production of very small terminal asci in crowded cultures. In cytological preparations from such cultures there is no suggestion of cell fusion in the formation of these minute asci nor was an enlarged fusion nucleus ever observed (FIG. 31-35). A second noteworthy variation is the production of very small intercalary asci when the organism is grown on a one per cent lactose agar. On this medium a very poor growth takes place and a complete range of variation in ascus size occurs from more or less normal elongate asci to undiffer-



FIGS. 36-43. Later stages in ascus formation. 36-41, four to thirty-two nucleate stages, $\times 1550$; 42, formation of spores, from a lactophenol preparation of an agar culture, $\times 775$; 43, mature ascus, $\times 1550$.

entiated hyphal cells which may contain less than eight spores (FIG. 44-50). In some cases there is evidence of a previous fusion of cells in the formation of these asci (FIG. 50), but it seems probable that the smaller ones may be developed parthenogenetically.

TECHNICAL DESCRIPTION

Dipodascus uninucleatus sp. nov.

Hyphii ramosis, septatis, ad septa constrictis, sine conidiis, $2.4-2.6 \mu$ crassis; cellis uninucleatis; ascis longe cylindraceis, sursum attenuatis, multisporis, $7-8 \times 90-180 \mu$; ascosporis ellipsoideis, $0.5-1.0 \times 2.0-2.8 \mu$.

Colony circular pulvinate; edge wavy, surface glistening, gyrosely wrinkled; consistency butyrous; color opaque; coloration of the medium none. Hyphae branched, septate, constricted at the cross walls, $2.4-2.6 \mu$ in diameter in young cultures, in old cultures very irregular. Asexual reproduction none. Cells consistently uninucleate. Asci elongate, multisporeous, diameter $7-8 \mu$ tapering to $4-5 \mu$ at the tip, length extremely variable, in young cultures $90-180 \mu$. Spores minute ellipsoid $0.5-1.0 \times 2.0-2.8 \mu$, liberated from the tip of the ascus by gradual extrusion.

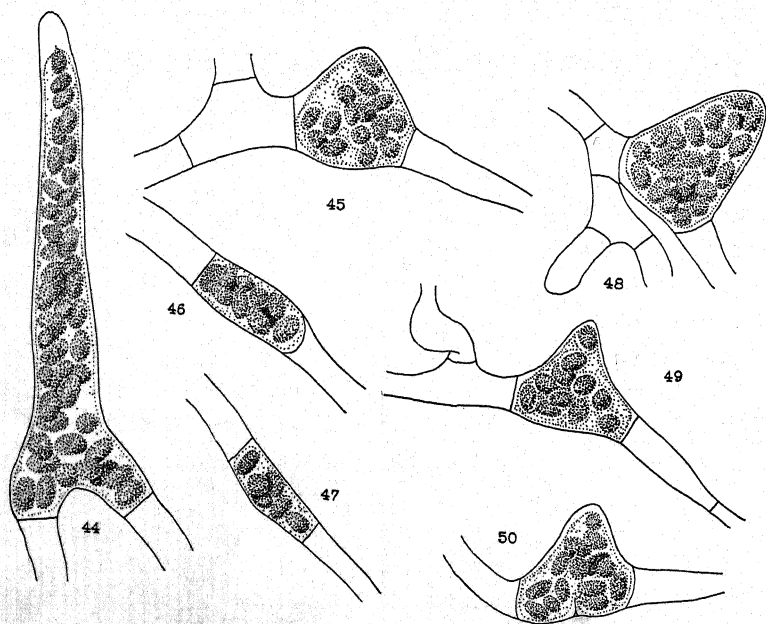
The cultures of *Drosophila melanogaster* from which *D. uninucleatus* was obtained were maintained as genetics class material in the Department of Botany in the University of Toronto.

Slides of this organism have been deposited in the Herbaria of the Universities of Toronto, Harvard and Cornell. Cultures have been deposited with the mycological laboratories at the above Universities and in the American Type Culture Collection at Chicago, Illinois and in the Centraalbureau voor Schimmelcultures at Baarn, Holland.

DISCUSSION

Dipodascus uninucleatus shows relationship to *Dipodascus albidus* in the structure of the mature asci and in the method of formation and liberation of the spores. On the other hand the limited, somewhat yeast-like growth, the uninucleate cells and the small asci developed on lactose agar are reminiscent of the Endomycetaceae. Recent investigations of *Ascoidea rubescens* are of interest in this connection. In this organism the asci develop from multinucleate hyphal tips either with (Varitchak 9) or without

(Walker 11) a fusion of nuclei. The mature asci are multi-spored and the spores have the peculiar hat shape characteristic of certain species of *Endomyces* and Saccharomycetaceae. *Ascoidea rubescens* shows relationship to *Dipodascus albidus* in the development of the asci from multinucleate cells and also shows affinities with Saccharomycetaceae in the characteristic shape of the spores. The present study and the recent work on *A. rubescens* indicates that *Dipodascus albidus* no longer occupies the very isolated position usually assigned to it but is connected to the



FIGS. 44-50. Abnormally small asci developed on a one per cent lactose agar. 44, ascus of reduced size retaining the normal elongate form; 45-49, various greatly reduced asci; 50, an ascus showing indications of a previous fusion of cells. All figures $\times 1550$.

Endomycetaceae through both *D. uninucleatus* and *A. rubescens*. It might even be justified to question the necessity for placing this genus in a special family.

In the light of this evidence the apparently phycomycetous characters of *D. albidus* may have less significance than has been given them. With regard to the coenocytic cell structure, this

character shows considerable variation in Endomycetaceae and even within the genus *Dipodascus*. Further a comparison of ascus development in *D. uninucleatus* and *D. albidus* shows that the presence of supernumerary nuclei within the ascus of the latter is a direct consequence of the multinucleate cell structure. Finally multisporeous varieties occur in many orders of the higher Ascomycetes and there would seem to be little justification for considering this character to be of greater significance in one group than in another.

A critical review of the general characters of the fungi included in the Hemiascomycetes of Varitchak (9) and in the Endomycetales strongly suggests that they may be a collection of reduced forms. Most of the genera occupy special habitats. All the genera so far reported are homothallic and on genetical grounds it would appear that heterothallism is necessary for progressive evolution. The marked tendency to parthenogenesis in all the genera could well be correlated with a loss in the significance of the sexual process through homothallism. Finally all these fungi are more or less related to the Saccharomycetaceae (6) which are generally recognized to be reduced.

The hypotheses involving the origin of the Ascomycetes from the Phycomycetes through the Endomycetales all presuppose that this order has been derived from an ancient transitional group combining the characters of both Ascomycetes and Phycomycetes. This assumption is at present with little foundation and the equally possible method of origin from higher forms by reduction should at least be considered. Until further evidence is available it would seem best to view the problem of the phylogeny of the simpler Ascomycetes with an open mind in order that the accumulating evidence may be correctly assessed.

SUMMARY

Dipodascus uninucleatus was obtained in culture from a dead pupa of *Drosophila melanogaster*. The vegetative growth is yeast-like and no asexual reproduction occurs. The fungus is homothallic. The cells are consistently uninucleate. The asci arise from the fusion of two undifferentiated uninucleate cells and develop after nuclear fusion. The mature asci are elongate, multi-

spored and bear a marked resemblance to those described for *Dipodascus albidus* Lag.

D. uninucleatus possesses characters which suggest a closer relationship of the genus *Dipodascus* with the Endomycetaceae than has hitherto been recognized.

DEPARTMENT OF BOTANY,
UNIVERSITY OF TORONTO,
TORONTO, ONTARIO, CANADA

LITERATURE CITED

1. Atkinson, G. F. Phylogeny and relationships in the Ascomycetes. Ann. Missouri Bot. Gard. 2: 315-376. 1915.
2. Brefeld, O. Untersuchungen aus dem Gesamtgebiete der Mykologie 9: 49-108. 1891.
3. Dangeard, P. A. Recherches sur le developpement du périthèce chez les Ascomycètes. Le Botaniste 10: 1-385. 1907.
4. —. Le reproduction sexuelle envisagée dans sa nature, dans son origine et dans ses conséquences. Le Botaniste 13: 285-327. 1910.
5. Gäumann, E. A. & C. W. Dodge. Comparative morphology of the Fungi. 393-395. 1928.
6. Guilliermond, A. Recherches cytologique et taxonomique sur les Endomycètes. Rev. Gen. Bot. 21: 401-419. 1909.
7. Juel, H. O. Über Zellinhalt, Befruchtung und Sporen bildung bei *Dipodascus*. Flora 91: 47-55. 1902.
8. Lagerheim, G. de. *Dipodascus albidus* eine neue, geschlechtliche Hemiascee. Jahrb. Wiss. Bot. 24: 549-565. 1892.
9. Varitchak, B. Contribution à l'étude du developpement des Ascomycètes. Le Botaniste 23: 1-183. 1931.
10. Walker, Leva B. Studies on *Ascoidea rubescens*. I. History and development. Mycologia 23: 5-76. 1931.
11. —. Studies on *Ascoidea rubescens*. II. Cytological observations. Mycologia 27: 102-127. 1935.

NEW AND UNUSUAL AGARICS FROM THE WESTERN UNITED STATES ¹

ALEXANDER H. SMITH

(WITH 3 FIGURES)

While studying the species of *Mycena* (14) occurring in Washington, Oregon and California during the fall of 1935 many agarics in other genera were also collected. Fifteen of the more outstanding species are critically discussed or described in this paper. Four new species are described, and three, *Clitocybe albi-formis* Murrill, *Psilocybe ochraiceps* Kauffman, and *Naucoria elatior* (Peck) Sacc. are reduced to synonymy. Particular attention was given to species of *Naucoria* in the section segregated as the genus *Phaeocollybia* by Heim (5). Five species in this group, including two that are new, are critically compared.

The collection numbers and photographs are the writer's unless otherwise stated. All the collections are deposited in the herbarium of the University of Michigan.

CLITOCYBE ALBISSIMA (Peck) Sacc.

Pileus 6.5–11 cm. broad, broadly convex to nearly plane, seldom slightly umbonate, the margin at first inrolled and under a lens appearing cottony pubescent, surface dry, dull and unpolished, usually ribbed near the whitish margin, the disk cream colored or with a faint tinge of tan; flesh thick and firm, white, dry, odor faintly fragrant, taste mild; lamellae pure white, crowded, narrow, many forking once near the stipe, decurrent by long lines which occasionally anastomose, not readily separable; stipe 8–15 (20) cm. \times 1.5–2 (3) cm., equal or clavate, white, dry, pruinose scurfy to pubescent above or rather evenly covered by minute innate squamules, base often with a white cottony mycelium, solid, flesh white; spores 7–8 \times 4–5 μ , ellipsoid, echinulate, dark violet with iodine in chloral hydrate; basidia four-spored; cystidia not differentiated; pileus trama homogeneous, cuticle of a compact layer of narrow subparallel hyphae.

¹ Papers from the Department of Botany and the Herbarium of the University of Michigan, no. 588.

Gregarious around redwood stumps, Trinidad, Calif., Nov. 27, 1935, H. E. Parks and A. H. Smith (3626). This species is close to *Clitocybe piccina* Peck, but is readily distinguished by the mild taste and pure white gills. The spores of both species stain dark blue in iodine, are echinulate and measure $7-8 \times 4-5 \mu$. The western form is larger than that usually considered typical, and in certain respects it approaches *Clitocybe gigantea* Fries. *Clitocybe albiformis* Murrill is only a large form of *C. albissima*. The spores of Murrill's type are minutely echinulate, stain dark violet in iodine in chloral hydrate, and measure $6-7 \times 4-4.5 \mu$.

COLLYBIA UMBONATA Peck.

Pileus 4-8 (10) cm. broad, obtusely conic, becoming expanded and conspicuously umbonate, faintly fibrillose-pruinose under a lens, soon glabrous, "chestnut-brown"² on the disk, "hazel" toward the margin, at times "russet" or "bay" on the umbo and "buckthorn brown" near the margin, hygrophanous, fading to "warm buff" near the margin, the disk remaining somewhat darker, surface smooth or radially rugulose; flesh thick under the umbo, tapering gradually to the margin, buffy tan in color, pliant and very cartilaginous, odor and taste not distinctive; lamellae close, narrowly and deeply adnexed, broad, tapering evenly to the margin, pale buff ("warm buff"), becoming slightly darker, edge slightly uneven, at times slowly changing to brownish when bruised; stipe 8-10 (12) cm. \times 6-10 mm., strict, glabrous and equal above a long pseudorhiza, smooth or at times twisted and striate due to the longitudinal splitting of the cuticle, concolorous with pileus or more yellowish brown, hollow, very cartilaginous; spores $5-6 \times 3 \mu$, smooth, hyaline, ellipsoid; basidia four-spored; cystidia very abundant on sides and edges of lamellae, $57-86 \times 8-15 \mu$, fusoid-ventricose, smooth; pileus trama covered by a thin surface pellicle through which large cystidia project, beneath this a compact pseudoparenchymatous layer of slightly enlarged cells, the remainder floccose and filamentose.

Single to gregarious under redwoods, Prairie Creek State Park, Oric, Calif., Nov. 30 (3683), Dec. 3 (3733), and Dec. 4, 1935 (3770). The microscopic characters of the type at the New York State Museum, Albany, N. Y., are exactly as described above. The species which Kauffman (9) described under the name *Col-*

² All color names in quotation marks are taken from Ridgway, R. Color Standards and Nomenclature, Washington, D. C. 1912.

lybia umbonata Peck differs from the above by the absence of cystidia on the gills, the larger spores, habitat on wood, the odor of benzaldehyde, and slowly bitterish taste. It is here considered to be an undescribed species.

***Collybia oregonensis* sp. nov.**

Odor distinctissimus; pileus 4-10 cm. latus, conico-campanulatus vel umbonatus, testaceo-fuscus, lubricus; lamellae angustae, adnexae, confertae, latae, albae vel pallidae, acie concolores; stipes 10-20 (30) cm. longus, 5-15 (20) mm. crassus, fusiformiter radicans, glaber, levis vel subsulcatus, pallide brunneus; sporae $6-8 \times 3.5-4.5 \mu$; cystidia nulla.—Specimen typicum in Herb. Univ. Mich. conservatum: legit C. H. Kauffman, prope Takilma, Oregon, Nov. 29, 1925.

GOMPHIDIUS ROSEUS (Fries) Quél.

Pileus 3-7 (10) cm. broad, convex, becoming plane, occasionally slightly umbonate, surface covered by a glutinous layer, disk "Carmelian red" at first and fading to "carrot red," the margin paler and "flesh color" to "pale flesh color" or in age whitish with a faint incarnate tinge, glabrous; flesh thick, white, occasionally tinged reddish near the cuticle, tapering rather abruptly near the margin; odor and taste none; lamellae white, rather close, narrow, forking once or sometimes twice, dull blackish brown in age, deeply decurrent; stipe 6-12 cm. \times 10-15 mm., equal above a clavate base, at first white and coated with a glutinous sheath to the superior annular zone, white and subscabrous above, base of stem white or whitish, at times faintly yellowish, the gluten blackening in age causing discolored patches; spores $14-18 \times 4-5.5 \mu$, subfusiform to subcylindric, apices obtuse, dull smoky brown under the microscope; cystidia scattered on the sides of the gills $90-120 \times 8-10 \mu$, cylindric.

Scattered under conifers, Lake Crescent, Wash., Oct. 1 (2772), and Oct. 3, 1935 (2839). Kauffman (7) pointed out that *Gomphidius subroseus* differs from *G. roseus* "by the distinct yellow base of the stem, by the less rosy red color of the pileus and perhaps by the cystidia." The writer's material differed from *G. subroseus* in the brighter colors and white or faintly yellowish tinged exterior of the base of the stem, the almost scabrous apex of the stipe, and by the blackening gluten on the stem. The cystidia are alike in both species. *G. roseus* was very abundant in the vicinity of Lake Crescent during the season of 1935 and

closely rivaled *Gomphidius oregonensis* Peck as the commonest agaric in the woods.

HYPHOLOMA DISPERSUM (Fries) Quél.

Pileus 1–3.5 (4) cm. broad, conic to convex, broadly umbonate in age, glabrous on the disk, faintly silky near the appendiculate margin, at first "ochraceous-orange" to "ochraceous-tawny," becoming "honey yellow" to "Isabella color" near the margin or at times sordid olive yellow, the disk becoming sordid tawny, subhygrophanous, fading slowly to sordid "ochraceous-buff" or "warm buff," lubricous when moist and not striate; flesh rather watery but firm, whitish or sordid olivaceous to yellowish, odor not distinct, taste slightly bitterish and unpleasant; lamellae broad, adnate, close, white at first, becoming sordid olive and finally purplish brown, edge whitish; stipe 6–10 cm. \times 2–5 mm., covered by a dense silky fibrillose layer to near the pruinose apex, at times with faint fibrillose patches or subannular fibrillose zones over the lower portion, dark reddish brown to bistre beneath the fibrils in the lower portion, paler above and yellowish, equal above a somewhat enlarged base, rather tough and pliant, brittle in slender forms; spores $7-9 \times 4-5 \mu$, smooth, sordid reddish brown under the microscope; cystidia abundant on the sides, $32-48 \times 8-10 \mu$, smooth, midportion inflated, apex abruptly narrowed to an almost papillate point, on the edges $18-22 \times 6-8 \mu$, smooth and fusoid-ventricose.

Densely gregarious on the very decayed remains of fir logs, on chips and debris where timber has been cut or on the humus and debris usually present on the forest floor, Olympic Hot Springs, Sept. 29 (2672); Lake Crescent, Oct. 10 (3007); Sol Duc Hot Springs, Oct. 17 (3205); and near La Push, Wash., Oct. 26, 1935 (3344 and 3345). In California one collection was found at Trinidad Nov. 29, 1935 (3656). During October this was one of the commonest agarics in the Olympic Peninsula. Zeller (16) reports it from Oregon. The writer's collections agree very well with Fries' (2) description and illustration (3). The cystidia on the sides of the gills are similar to those found in *Hypholoma fasciculare* and *Hypholoma capnoides*. *Psilocybe ochraceps* Kauffman (8) is identical with *H. dispersum*. Cystidia similar to those described above were found abundantly on the sides of the gills in Kauffman's type. Since *H. dispersum* is

commonly described as having a stiff elastic stem that character alone should not be used to separate a species. In my material slender forms were found to have a stem which would snap when bent whereas in larger fruiting bodies this character was not evident. All variations in size and consistency were commonly found in single localities. Kauffman's collections of *P. ochraiceps* from the Olympic Peninsula clearly show the appendiculate margin of the pileus and the silky fibrillose stipe. The colors of the cap are apt to be rather variable and darker than given in Kauffman's description. A sterile form (3345) was found in which the yellow color was very pronounced. The gill surfaces were pale yellow, and the edges bright sulfur yellow. The pilei were either entirely yellow or with orange to "ochraceous-tawny" disks. The stems and the strigose hairs at their bases were also bright sulfur yellow. This form was found intermingled with fertile fruit-bodies. Immature individuals of the two forms could not be separated.

LEPIOTA SOLIDIPES Peck (FIG. 1).

This species is characterized by a layer of upright subgelatinous hyphae over the surface of the pileus which causes it to feel slippery when wet and to appear polished when dry. When dry the surface layer is sometimes cracked irregularly but does not become scaly. The color varies from white to "pale pinkish buff." The peculiar hyphae over the surface of the cap, the firm consistency and the very strong farinaceous odor and taste are distinctive. The spores measure $4-5.5\ \mu$ and are yellowish in iodine with chloro hydrate. The writer's collection from Crescent Beach, Joyce, Wash., Oct. 3, 1935 (2844) compares very well with the type at Albany, N. Y.

Naucoria attenuata sp. nov. (FIG. 2).

Pileus 1.5-5 cm. latus, obtuse conicus, demum late umbonatus vel planus, glaber, lubricus, fulvus, hygrophanus, demum sordide alutaceus, cartilagineus; caro odore subraphanoidea, sapore valde amara; lamellae confertae, angustae, subliberae, pallidae vel pallide caesiae, demum fulvae; stipes 10-12 cm. longus, 3-5 mm. crassus, valde radicans (3-8 cm.), glaber, politus, valde cartilagineus, fulvus demum spadiceus; sporae $7-8 \times 4-4.5\ \mu$, asperulae.—Specimen typicum in Herb. Univ. Mich. conservatum: legit A. H. Smith n. 3343, prope La Push, Washington, Oct. 26, 1935.

Pileus 1.5–5 cm. broad, obtusely conic, becoming broadly umbonate or broadly convex to plane in age, margin inrolled at first and in age often undulate, glabrous and polished, lubricous, "amber brown" when moist or near "ochraceous-tawny," hygroph-anous, fading to "ochraceous-buff" or "warm buff," margin seldom striatulate at any stage; flesh thin but cartilaginous, buff or watery brown, odor strong, somewhat radish-like, taste very disagreeable; lamellae close, narrow, equal, attached by a tooth, nearly

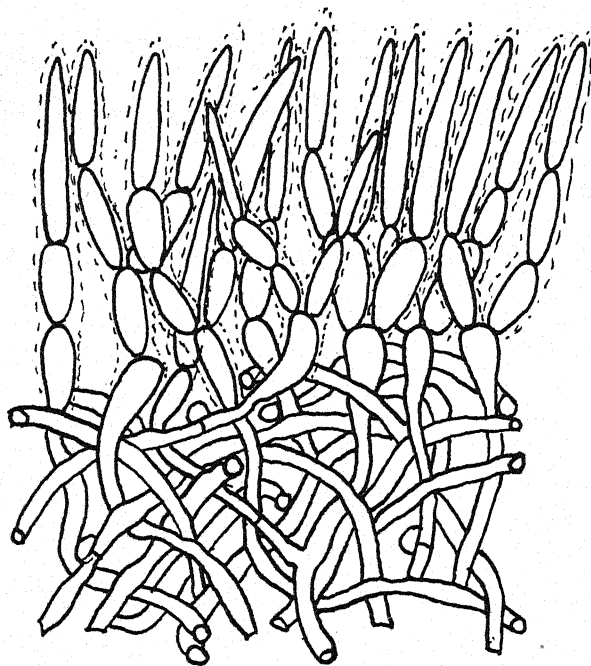


FIG. 1. *Lepiota solidipes* Peck. Tangential section showing the cuticle of the pileus. $\times 375$.

free in age, pallid and with a faint caesious tinge at first, pale cinnamon brown in age, edge even; stipe 10–12 cm. \times 3–5 mm. equal above a long (3–8 cm.) tapering pseudorhiza, glabrous and polished, hollow, very cartilaginous, at first pallid brownish over all; spores $7-8 \times 4-4.5 \mu$, almond shaped, roughened; basidia four-spored; cystidia not differentiated; pileus trama with a thin subgelatinous pellicle, beneath this a compact area appearing cellular in tangential section, the remainder filamentose.

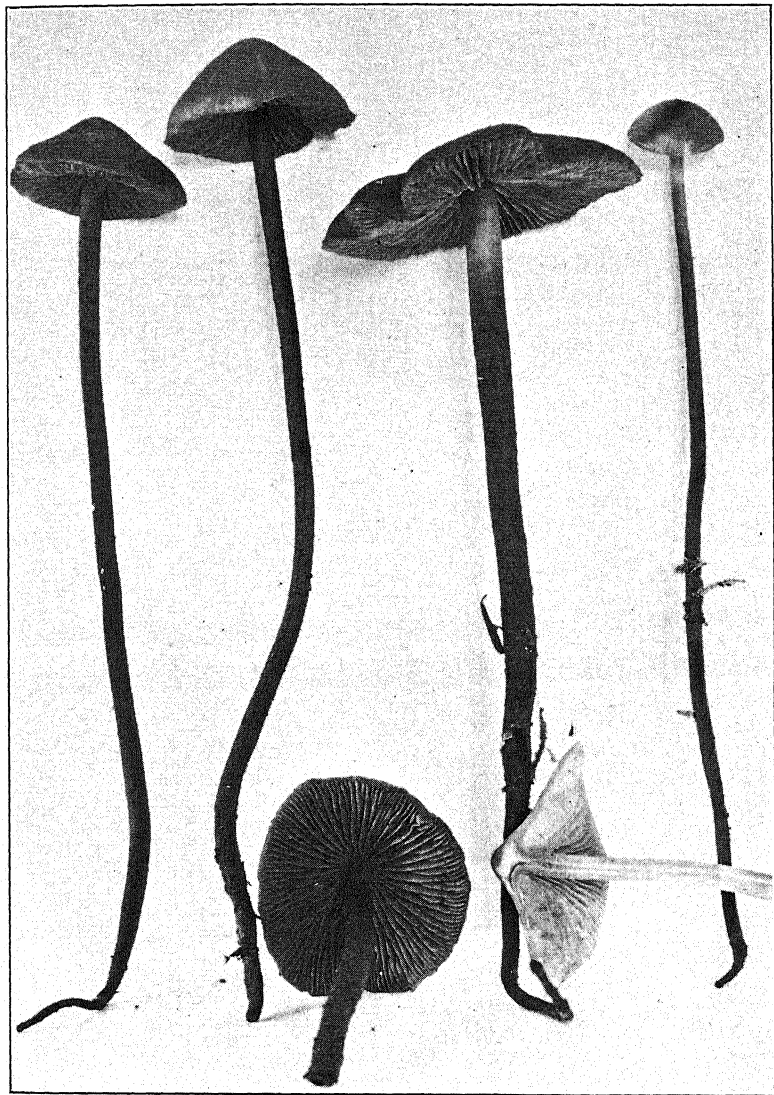


FIG. 2. *Naucoria attenuata* Smith. $\times 1$.

Closely gregarious under spruce, near La Push, Wash., Oct. 26 (3343-*type*), Oric, Calif., Dec. 4 (3769), Dec. 5 (3813), Dec. 7 (3876); north fork of the Mad River, Calif., Dec. 9, 1935 (3900). This species can be distinguished macroscopically by its stipe which blackens in age, by the very disagreeable taste, the polished lubricous pileus and stipe, the ochraceous colors and the closely gregarious manner of growth. Microscopically the distinctly roughened spores separate it at once from *Naucoria radicata* Murrill. Murrill (10) in his description of the latter mentions that its stipe also blackens. All of the writer's collections in which the stems blackened were found to have rough spores. The European species which appear to be most closely related are *Naucoria similis* Bres. and *Naucoria flava* Bres. The former is at once excluded by its color and the viscosity of the pileus. *N. flava* judging from descriptions, can be distinguished by its yellow color and silky to subfloccose pileus. *Naucoria Jennyae* Karsten is close but is said to have smaller spores and brighter orange colors.

***Naucoria Kauffmani* sp. nov. (FIG. 3).**

Pileus 8-15 (19.5) cm. latus, obtuse, conicus vel convexus, demum late umbonatus, glaber, glutinosus, pallide testaceus demum hepaticus, subhygrophanus, cartilagineus; lamellae confertae, liberae vel subliberae, latae; stipes 20-40 cm. longus, 1.5-3.5 (4) cm. crassus, valde radicans, apice pallide incarnatus, deorsum livido-brunneus vel spadiceus, valde cartilagineus; sporae 8-10 \times 4.5-6 (7) μ , asperulae.—Specimen typicum in Herb. Univ. Mich. conservatum: legit A. H. Smith n. 3523, prope Lake Tahkenitch, Oregon, Nov. 18, 1935.

Pileus 8-15 (19.5) cm. broad, convex to obtusely conic, becoming expanded and broadly umbonate, glabrous, very glutinous at first, margin long remaining inrolled and never striate, when moist "cinnamon," "light pinkish cinnamon," "cinnamon-rufous" or "Kaiser brown," becoming "liver brown" when old and water soaked, subhygrophanous, fading to "ferruginous" or "apricot orange"; flesh thick and firm, with a thick cartilaginous rind near the surface, "army brown" when moist, incarnate buff when faded, taste slightly farinaceous, odor not distinct; lamellae crowded, free or slightly attached by a tooth, narrow at first, broad (2 cm.), in age, at first "tilleul buff" becoming nearly "verona brown" in age; stipe 20-40 \times 1.5-3.5 (4) cm. gradually tapering downward to a long thread-like pseudorhiza, "buff-pink" to "onion-skin pink" above, sordid purplish brown below, becoming

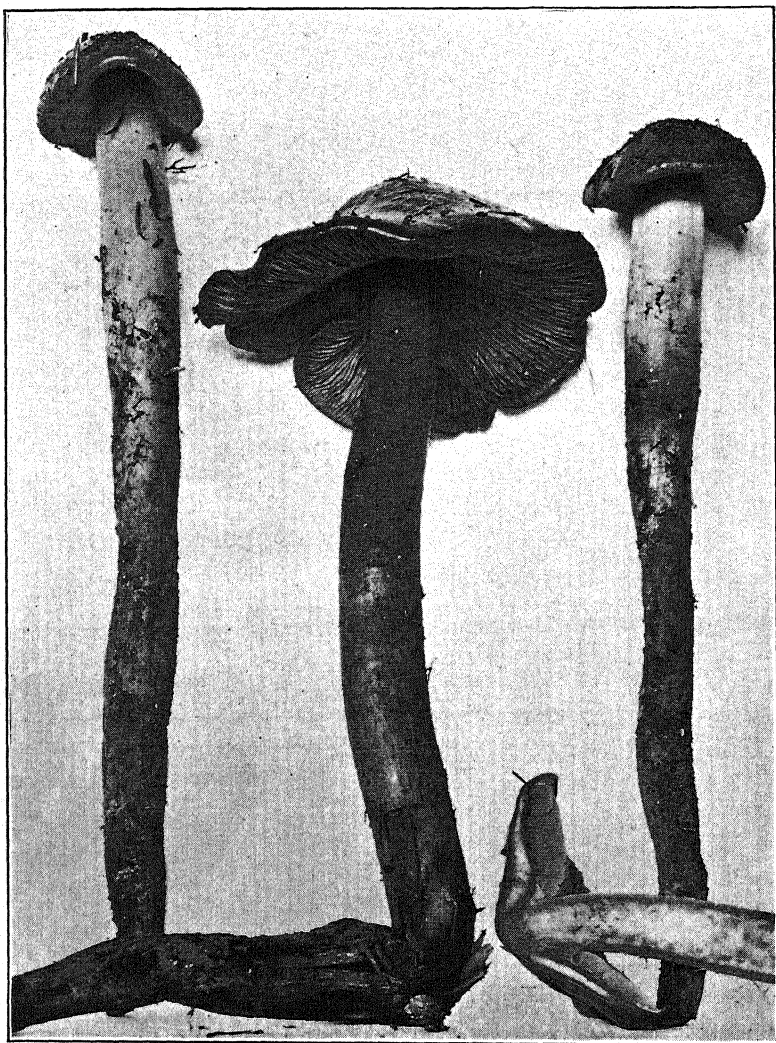


FIG. 3. *Naucoria Kauffmani* Smith. Very small immature fruit-bodies.
× 1.

darker to nearly black in age, stuffed with a pallid pith, with a thick cartilaginous rind, glabrous or faintly longitudinally striate at the apex; spores $8-10 \times 4.5-6$ (7) μ , pale cinnamon brown in mass, almond shaped, slightly roughened; basidia four-spored; cystidia on the gill edge only, $30-36 \times 5-7$ μ , narrowly clavate, smooth; pileus trama with a thick gelatinous layer over the surface, beneath it a compact pseudo parenchymatous layer of somewhat enlarged cells, the remainder floccose.

Gregarious to scattered under conifers, Lake Quinault, Wash., Oct. 11, 1925, and Takilma, Oregon, Dec. 7, 1925 (C. H. Kauffman). Under spruce at Cape Flattery, Wash., Sept. 18 (2495); Hoh River Valley, Wash., Oct. 7 (3024); La Push, Wash., Oct. 26 (3339); Lake Tahkenitch, Oregon, Nov. 18 (3523-type); and along the north fork of the Mad River, northern Calif., Dec. 9, 1935 (3888). The colors of *Naucoria lugubris* Fries and *N. Kauffmani* are very similar and quite variable. The spores are the most reliable character for separating the two species. Those of *N. Kauffmani* always measure 8 μ or more long and are up to 6 or 7 μ broad, those of *N. lugubris* to judge from the writer's collection and the statements of Heim (4), Ricken (12), Velenovsky (15) and Bresadola (1) seldom measure over 8.5 μ . The difference in the size of the fruit-body is relatively constant but should be used with caution since *N. lugubris* along our west coast is larger than the size usually given for the species in Europe. In *N. lugubris* the stipe and gills become bright fiery orange or reddish brown in age or where bruised whereas in *N. Kauffmani* the gills do not change and the stem becomes sordid purplish brown to blackish.

NAUCORIA CAESPITOSA Murrill.

Gregarious to subcespitose around redwood logs, Trinidad, Calif., Nov. 27 (3627), Nov. 30 (3679), Oric, Calif., Dec. 4 (3768) and Dec. 5, 1935 (3828). The colors of the fresh pilei are "pinkish buff" or dull whitish. At times the disk is "pinkish cinnamon." The margin of the pileus is at first beautifully fimbriate, and the stipe is sheathed by a loose fibrillose sheath up to the evanescent annular zone. The surface of the pileus is covered by a gelatinous pellicle which causes it to feel viscid. In wet weather this layer may be entirely washed away. The spores of the type measure $7-8$ (9) $\times 4-5$ μ , the basidia are four-spored and cystidia $25-31 \times$

8-15 μ are imbedded in the hymenium. The cystidia are smooth, colorless and ventricose with obtuse apices.

NAUCORIA CUCUMIS (Fries) Gillet.

The small form described by Josserand (6) was not uncommon in old pastures and along the edges of thickets. The pilei measured from 5 to 15 mm. broad. It was collected at Joyce, Wash., Oct. 11 (3105), and Lake Crescent, Wash., Oct. 14, 1935 (3144).

NAUCORIA FESTIVA (Fries) Bres.

Pileus 1-5 (6) cm. broad, conic at first, expanded and with a conic umbo at maturity, at times paler in age, glabrous, glutinous when wet, viscid in dry weather, "deep olive" to "buffy olive" when fresh, subhygrophanous, fading to "water green" or "vetiver green," margin faintly striatulate when fading; flesh thick on the disk, thinner toward the margin, "olive-green" to greenish gray, fading to greenish buff, very cartilaginous and brittle, taste mild or slightly bitter, odor faint and radish-like if flesh is crushed; lamellae close, free or adnexed and attached by a tooth, narrow, in age moderately broad near the margin, at first "pale violet-plumbeus" to "deep plumbago gray," soon grayish, finally brown, edge serrate or eroded; stipe 8-12 cm. \times 4-8 (12) mm., tapering slowly into a long pseudorhiza, at first faintly grayish to caesious at the apex and watery orange to reddish brown below, apex pale grayish green in some and brilliant orange red to blood red below, at first scantily covered by very minute bran-like scales or appressed fibrillose patches to near the apex, glabrous in age, tubular, rind thick and cartilaginous; spores 7-8.5 \times 4-5 μ , almond shaped, roughened; basidia four-spored; cystidia on gill edge only, scarcely differentiated, 35-42 \times 7-9 μ , clavate, apices obtuse, smooth; pileus trama with a thick gelatinous surface pellicle, beneath it a compact area of enlarged cells appearing pseudo-parenchymatous in tangential section, the remainder floccose.

Gregarious under spruce, La Push, Wash., Oct. 26, 1935 (3342); and under a stand of vigorous young redwoods, Trinidad, Calif.. H. E. Parks and A. H. Smith, Nov. 27 (3634) and Dec. 6, 1935 (3840). This species was rare in Washington but very abundant in the single locality on Mr. Parks' estate at Trinidad. The above collections were all characterized by the distinctly grayish violet gills of the young fruit-bodies and the faintly caesious tinge at the apex of the stems. The olive green viscid pileus, the stipe with its

scant fibrillose patches and the brilliant orange to reddish base in age, the long pseudorhiza, and spores clearly place our collections in this species. Judging from the descriptions of various European investigators, the colors and color changes of the gills and stems are quite variable. Violet colors on the stipe are mentioned by Ricken (12). The older pilei in the Trinidad material were spotted dark olivaceous umber. No yellowish spots were observed on any fruiting bodies.

NAUCORIA LUGUBRIS (Fries) Quél. sensu Ricken.

Pileus 4-8 (10) cm. broad, obtusely conic with an inrolled margin, in age expanded and obtusely umbonate or remaining broadly conic, glabrous, viscid or glutinous, opaque, near "fuscous" or "bone brown" when fresh, at maturity remaining dark or becoming almost "chestnut-brown," fading very slowly to "wood brown" near the margin, the disk remaining darker; flesh thick on the disk, tapering gradually, with a distinct cartilaginous layer near the surface, odor slightly farinaceous when cut or bruised, taste faintly bitter; lamellae free or scarcely attached by a tooth, narrow at first, moderately broad in age, close, pallid to near "avellaneous," becoming "snuff brown" finally "cinnamon-brown," staining ferruginous when bruised, edge serrate to eroded and slightly paler; stipe 15-20 \times 1-2 cm., tapering downward to a long (10-20 cm.) pseudorhiza, glabrous, polished, with very fine longitudinal striations, stuffed with a pallid buff pith, rind thick and very cartilaginous, concolorous with pileus or paler above and near "avellaneous," sordid reddish brown below, the reddish tinge increasing both in intensity and extent in age; spores 7-8 \times 4-5 μ , broadly almond shaped, rough; cystidia on the gill edge only, 30-35 \times 4-6 μ , clavate; basidia four-spored; pileus trama similar to that of *Naucoria Kauffmanii*.

Cespitose to gregarious in a spruce forest, Booth, Oregon, Nov. 13, 1935 (3458). The descriptions and illustrations of Fries (2), Rea (11), Bresadola (1) and Heim (4) depict a paler fungus. The essential characters however, are the smooth thick cartilaginous long-rooting stipe, the viscid pileus, small spores, and the color change on gills and stipe. Ricken (12) describes color variations of chestnut brown to chocolate gray which are close to those of my collection. In the larger clumps the stems were connate at their bases and penetrated deep into the soil. Because of the

fragile nature of the pseudorhiza and the difficulties of digging in the root-filled humus, the attachment was not ascertained. All of the forty odd fruiting bodies were either very near or under large fern clumps.

NAUCORIA MYOSOTIS (Fries) Quél.

Two fruiting bodies of this characteristic species were found along a path through swampy ground at Lake Ozette, Wash., Sept. 25, 1935 (2596). Since first collecting this species in Michigan (13) the writer has found it in the Adirondacks near the summit of Mt. Marcy and in a bog near Catlin Lake in the vicinity of Newcomb, N. Y. Specimens were sent to Dr. Kühner, Paris, who stated that microscopically the American material was similar to that of *N. Myosotis* in Boudier's herbarium. *Naucoria elatior* (Peck) Sacc. (*Agaricus elatior* Peck) is identical with the writer's material microscopically and should be considered a synonym of *N. Myosotis*.

NAUCORIA RADICATA Murrill.

Pileus 2-3 cm. broad, broadly convex with a small often inconspicuous conic umbo, glabrous and polished, lubricous to subviscid, margin faintly striatulate, "Kaiser brown" to "hazel" on the disk, margin "ochraceous-tawny" fading very slowly to near "apricot-buff," with a broad usually decurved sterile margin; flesh thick on the disk, thin toward the margin, soft and fragile, concolorous with the surface, odor and taste not distinctive; lamellae broad, crowded, narrowly adnexed, near "cinnamon-rufous" at maturity, edge slightly uneven; stipe 6-18 cm. long, 3-5 mm. thick, with a long (3-9 cm.) tapering pseudorhiza, concolorous with the pileus or paler, glabrous, polished, in age darker reddish brown or nearly chestnut below, not blackening, fistulose, very brittle; spores $5-6 \times 3-3.5 \mu$, subovoid, smooth, very pale ochraceous under the microscope, bright cinnamon brown in mass; basidia four-spored; cystidia on the gill edge only, $25-30 \times 3-5 \mu$, hair-like, apices acute; pileus trama with an adnate subgelatinous pellicle, beneath it a compact hyphal layer appearing pseudo-parenchymatous in tangential section, the remainder of floccose tissue.

Scattered under redwoods, Rush Grove, Prairie Creek State Park, Oris, Calif., Dec. 3 (3743), Dec. 3 (3746) Dec. 4 (3763)

and Dec. 7, 1935 (3875). The stipe darkens when the fungus is dried, but no such change was noted on even the old fruit-bodies in the woods. For additional comments see *Naucoria attenuata*.

NAUCORIA STICTICA (Fries) Sacc.

Gregarious under blackberry bushes at the side of a road, Lake Crescent, Wash., Oct. 13 (3121), and Oct. 23, 1935 (3312). To judge from the descriptions, the writer's collections differ from *Naucoria obtusa* Cooke and Massee in the larger size, longitudinally striate stem and broadly ovoid to subglobose roughened spores. *Naucoria innocua* according to Ricken has larger wedge shaped spores. Fries' (3) illustration of *N. stictica* depicts my material very well except for the minute white granules. The spores are rough, measure $6-7 \times 4-5 \mu$ and are broadly ovoid to subglobose. Cystidia are not differentiated and a thin gelatinous pellicle covers the pileus. At first the cap is evenly "Sanford's brown." It fades slowly to near "cinnamon-buff."

Psathyra pelliculosa sp. nov.

Pileus 8-20 mm. latus, conicus, glaber vel subfibrillosus, viscidus, saturate isabellinus vel pallide olivaceus demum incarnato-alutaceus; lamellae sordide fulvae, demum umbrinae, confertae, adnatae, angustae demum latae; stipes 6-8 cm. longus, 1.5-2 mm. crassus, apice pruinosis et pallide cinereus, deorsum sericeo-fibrillosus et umbrinus; sporae $8-10 \times 4-5 \mu$; cystidia 25-30 $\times 6-9 \mu$, ventricosa.—Specimen typicum in Herb. Univ. Mich. conservatum: legit A. H. Smith n. 3431, prope Lake Tahkenitch, Oregon, Nov. 11, 1935.

Pileus 8-20 mm. broad, sharply conic, scarcely expanding, margin appressed against the stem at first and for a time slightly appendiculate from the remains of the submembranous to fibrillose veil, glabrous at maturity, viscid, pellicle separable and tenacious, "Saccardo's umber" to "Isabella color" when moist, margin at times with a distinct greenish gray tinge, hygrophanous, fading to "pinkish buff," striatulate when moist; flesh thin and pliant, odor not distinctive; lamellae dull "cinnamon-brown," at maturity dark and smoky from the spores, close, adnate, seceding, narrow to moderately broad, edge whitish; stipe 6-8 cm. $\times 1.5-2$ mm., equal above an enlarged base, appressed silky fibrillose below, pruinose above, brownish to near "bister" toward the base, apex pallid to grayish, tubular, rather pliant but rigid; spores $8-10 \times 4-5 \mu$, dull purple brown under the microscope, ellipsoid; cystidia abundant

on the gill edge, $25-30 \times 6-9 \mu$, smooth, inflated, fusoid-ventricose with an acute apex; pileus trama homogeneous below a thick gelatinous pellicle.

Gregarious on moss and debris, Lake Crescent, Wash., Oct. 10 (3074); Sol Duc Hot Springs, Wash., Oct. 17 (3196); Lake Tahkenitch, Oregon, Nov. 11 (3431-type); Siltcoos Lake, Oregon, Nov. 13, 1935 (3461). The submembranous partial veil which adheres slightly to the margin of the pileus and the consistency relate this species to *Hypholoma dispersum*. The tenacious gelatinous pellicle on the pileus, the sordid colors which tend to become greenish and the silky fibrillose stipe relate it to *Psathyra fagicola* Lasch. It is distinguished from the latter by the presence of a partial veil, firm gills and smaller stature. Kauffman collected this species at Lake Cushman, Wash., Oct. 1, 1915, and again at Lake Quinault, Wash., during Oct., 1925.

UNIVERSITY OF MICHIGAN

LITERATURE CITED

1. Bresadola, J. Iconographia Mycologica fasc. 16. 1930.
2. Fries, E. M. Hymenomycetes Europaei. 1874.
3. ——. Icones Selectae Hymenomycetum. 1877.
4. Heim, R. *Naucoria (Phaeocollybia) lugubris* Fries. Bull. Soc. Myc. Fr. Atlas 46: pl. 39. 1930.
5. ——. Le Genre *Inocybe*. Encyclopédie Mycologique 1: 1-430. 1931.
6. Jossierand, Marcel. Notes Critiques sur Quelques Champignons de la Région Lyonnaise. Bull. Soc. Myc. Fr. 49: 340-376. 1933.
7. Kauffman, C. H. The genus *Gomphidius* in the United States. Mycologia 17: 113-126. 1925.
8. ——. The fungus flora of Mt. Hood, with some new species. Papers Mich. Acad. 5: 115-148. 1926.
9. ——. The fungous flora of the Siskiyou Mountains in southern Oregon. Papers Mich. Acad. 11: 151-210. 1930.
10. Murrill, W. A. N. Am. Flora. 10: 170-185. 1917.
11. Rea, Carleton. British Basidiomycetae. 1922.
12. Ricken, Adalbert. Die Blätterpilze. Theodor O. Weigel. 1915.
13. Smith, Alexander H. Unusual agarics from Michigan. II. Papers Mich. Acad. 20: 171-183. 1935.
14. ——. Studies in the genus *Mycena*. III. Mycologia 28: 410-430. 1936.
15. Velenovský, Jos. České Houby. 1920-22.
16. Zeller, S. M. New or noteworthy agarics from Oregon. Mycologia 25: 376-391. 1933.

PHOTOGRAPHS AND DESCRIPTIONS OF CUP-FUNGI—XXV. URNULA GEASTER

FRED J. SEAVER

(WITH 3 FIGURES)

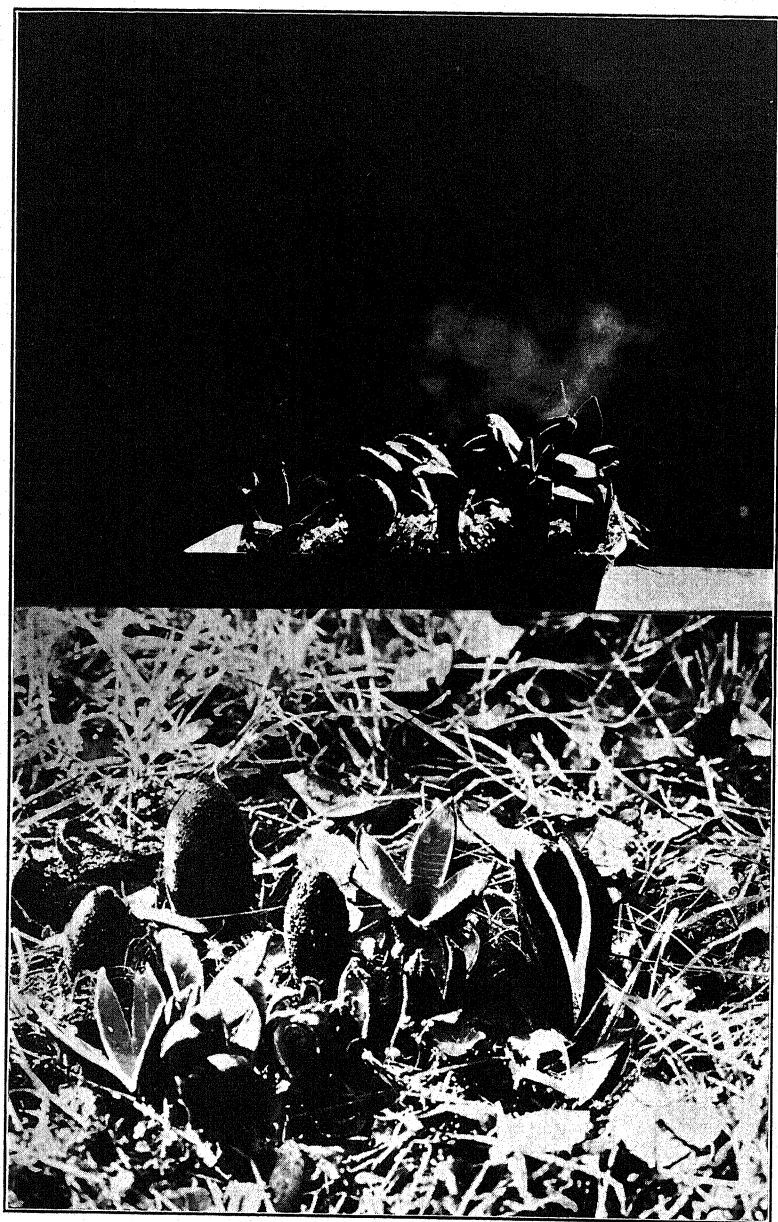
Since the publication of North American Cup-fungi (operculates) some interesting data and observations on *Urnulla Geaster* have come to the attention of the writer through Professor G. W. Goldsmith of the University of Texas, to whom I am indebted for the material and part of the photographs, on which the present paper is based.

DISTRIBUTION

This species was originally described by C. H. Peck from material collected at Austin, Texas. The material, on which the present paper is based, was collected in the same locality. So far as the writer knows this species has not been found outside of the State of Texas, although there seems to be no reason to believe that it might not occur over a wider range. When this material was received from Professor Goldsmith specimens were sent to Dr. J. A. Nannfeldt, the outstanding student of the cup-fungi of Europe at the present time, and he reported that he knew nothing like it in Europe. We conclude, therefore, that the fungus has a very limited distribution, and this in itself is interesting since the fungi are often cosmopolitan in their distribution.

STRUCTURE

The details of the structure of this fungus were thoroughly discussed by Doctors F. D. Heald and F. A. Wolf (Bot. Gaz. 49: 182. 1910). It is not necessary to go into the details of this at the present time, except to call attention to one important feature which they must have overlooked, although it is impossible for the writer to understand how this could possibly have been done. This has to do with the structure of the paraphyses.



FIGS. 1-2. *Urnula Geaster*.

PARAPHYSES

Doctors Heald and Wolf in their article state "Numerous branched septate paraphyses are present, which are uniform in diameter throughout (slightly less than 2μ) and do not show a terminal enlargement as figured by Kupfer." In examining the material sent by Professor Goldsmith, the writer was immediately impressed by what appeared to be strings of huge conidia interspersed with the asci, but which were found on closer examination to represent swollen paraphyses, each joint of which becomes ellipsoid or almost rounded, giving the whole the appearance of a string of miniature balloons. At first it was not apparent that these were paraphyses. However, it was finally noted that the terminal cells were scarcely swollen at all, and that the individual balloons were really the swollen cells of the paraphyses. The writer naturally began to look for a reason for this peculiar phenomenon.

EXPANSION APPARATUS

In looking at the figures accompanying this article it will be noted that this fungus, commonly known as the "devil's cigar," is at first cylindrical. Later it splits into several rays which fold back so that the apothecium is literally turned inside out. From this it will be readily seen that the swelling of the paraphyses is another ingenious device which facilitates the expansion or warping of the hymenium, thus placing the asci in such position that the spores may be freely discharged.

Although the writer has worked on the cup-fungi for many years, and while he has noted that the paraphyses are sometimes slightly swollen, nothing even approaching the condition encountered here has been observed before. What puzzles him most is the fact that this character was overlooked by Heald and Wolf while working on this material in Texas. This would lead one to suspect that possibly there are two species in Texas, one of which has swollen paraphyses, and the other the slender form. This, however, seems rather unlikely. This character should be carefully checked in the field in order to determine just how and when this swelling takes place. Unfortunately since this species is



FIG. 3. *Urnula Geaster*.

known only in Texas it is impossible to carry out these investigations from fresh material in New York, and the question, therefore, remains to be investigated more carefully by some local student.

SPORE DISCHARGE

So far as the writer is aware, Mr. W. R. Fisher, of Cornell University, was the first man to photograph the process of spore discharge in the ascomycetes. This has been done on two species of *Sclerotinia*, both inoperculate cup-fungi. Professor Goldsmith has made very excellent photographs of the spore discharge in *Urnuia Geaster*, which is apparently the first photograph of such spore discharge in an operculate cup-fungus. In this particular case the spores are many times larger than those of the *Sclerotinieae*, and should consequently produce a much denser cloud when discharged in mass.

DEHISCENCE OF THE ASCUS

In discharging the spores the ascus ruptures at one side near the apex and after discharge appears in profile rigidly upright, just as though one side of the ascus had been turned back. In face view the edge of the operculum is rounded, but it remains firmly attached on the other side. The ascostome then occupies an oblique position.

THE ASCOSPORES

The ascospores are usually large, reaching a length of 50–70 μ . They are attenuated at either end and their form and size would indicate that the contraction of the ascostome might facilitate their discharge, as has been pointed out for certain other species.

DISCUSSION

There are many points in connection with this species to be cleared up. Unfortunately, however, from the standpoint of the writer this species occurs only in Texas, and no opportunity has been afforded for first hand study of the fungus in the field. It

offers an excellent opportunity for study of the dehiscence of the ascus, the position of the ascostome, and the methods of spore discharge. It is hoped that these points may be worked out more in detail by some local student.

THE NEW YORK BOTANICAL GARDEN

EXPLANATION OF FIGURES

Fig. 1-3. *Urnula Geaster*. 1, photograph by G. W. Goldsmith of eos pore discharge, much reduced; 2, habitat group, also by G. W. Goldsmith, much reduced; 3, photograph of several plants made under the directions of the writer from material sent by G. W. Goldsmith, about $\frac{2}{3}$ natural size, with drawings of the ascus in various stages and the swollen paraphyses.

THREE DERMATEACEAE OCCURRING ON NEMOPANTHUS¹

J. WALTON GROVES²

(WITH 9 FIGURES)

During the course of a cultural study of conidial relations in the Dermateaceae, it was found that three quite distinct species of this group occurred on *Nemopanthus*, and at least two of them also on *Ilex*, and that these three fungi had been confused to a considerable extent in the past, especially in regard to their conidial relationships. This paper is presented with the aim of clarifying these relationships.

The three fungi which will be discussed are as follows: *Dermatea Peckiana* (Rehm), of which the imperfect stage is *Micropera stellata* (Ellis). Jacz.; *Godroniopsis Nemopanthis*, of which the imperfect stage is *Sphaeronema Peckii* Sacc. & Syd.; and *Durandiella Nemopanthis* (Peck), of which no imperfect stage has been found.

In the field these fungi are frequently found closely associated, sometimes all three occurring on the same twigs of the host. It sometimes happens that the perfect stage of one will be found associated with the imperfect stage of another, so that cultural studies are essential to the determining of their proper relationships. The fungi are quite distinct morphologically and once their relationships have been determined in this way they are readily recognizable.

¹ Contribution from the Department of Botany, University of Toronto, Toronto, Ontario.

² The writer wishes to acknowledge his indebtedness to Professor H. S. Jackson, under whose direction the work was carried on, for his continued interest and helpful suggestions; to Dr. Bessie B. Kanouse of the University of Michigan who kindly loaned the specimen of *Micropera caespitosa* (Peck) Archer on which this combination was based; and to Mr. J. Herbert Stewart, head of the department of Classics at Woodstock Collegiate Institute, who assisted with the Latin diagnosis.

The material used in this study was collected, for the most part, in the Temagami Forest Reserve, Ontario. The method employed was to obtain cultures from both ascospores and conidia as found in nature, and to compare the cultural characters and type of conidial stage produced in culture. The cultures were grown on two per cent agar containing two per cent malt extract, and on sterilized twigs of the host. The twig cultures were grown in flasks which were prepared in the following manner. Healthy twigs were selected and cut into lengths of 7-10 cm. and three of these were placed in a 300 cc. Erlenmeyer flask with about 25 cc. of water. The flasks were then sterilized for half an hour in the autoclave at fifteen pounds pressure. When cool the twigs were inoculated by placing bits of agar and mycelium in slits which had previously been cut in the bark, and these flasks were kept on a shelf in the laboratory at room temperature and in diffuse light. Polysporous cultures of both ascospores and conidia were used in the hope of facilitating the development of the perfect stage. No ascogenous stage developed in any of the cultures, however. In studying the morphology of the fruiting bodies free-hand sections and crushed mounts were used exclusively.

Dermatea Peckiana (Rehm) comb. nov.

Cenangium Peckianum Rehm, Ann. Myc. 13: 3. 1915.

Sphaeronema stellatum Ellis, Bull. Torrey Club 6: 107. 1876.

Sphaerographium stellatum Sacc., Syll. Fung. 3: 598. 1884.

Micropera Nemopanthis Peck, Ann. Rep. N. Y. St. Mus. 46: 109. 1893.

Micropera stellata Jaczewski, Nouv. Mem. Soc. Imp. Natur. Moscow 15: 366. 1898.

Apothecia arising from the old conidial stroma, caespitose, crowded, up to 15 in a cluster, about 0.3-0.8 mm. in diameter and the clusters up to 1 mm. in height, circular or irregular in outline, slightly narrowed below, dark brown to black but the basal stroma pale yellowish, hard, leathery to horny in consistency becoming more fleshy-leathery when moist; hymenium at first concave becoming plane or convex, dark brown to black, slightly roughened, with a brownish margin which is at first raised and more or less infolded, later almost disappearing; tissue of the stroma compact, pseudoparenchymatous, composed of hyaline, thick walled cells

about $8-20 \times 5-10 \mu$ arranged in more or less vertically parallel rows, curving obliquely toward the outside where the cells are smaller, more globose, and with thicker and darker walls; subhymenium composed of slender, closely interwoven hyphae; asci cylindric-clavate, tapering to a slender stalk, eight spored, $67-110 \times 9.5-12.5 \mu$; ascospores ellipsoid to subcylindric or subfusiform, hyaline or pale yellowish, straight or slightly curved, one to two (to four?) celled, $10-23 \times 3-6 \mu$; paraphyses hyaline, filiform, septate, branched, $1.5-2 \mu$ in diameter, the tips swollen to $3-5 \mu$ and forming an epithecium.

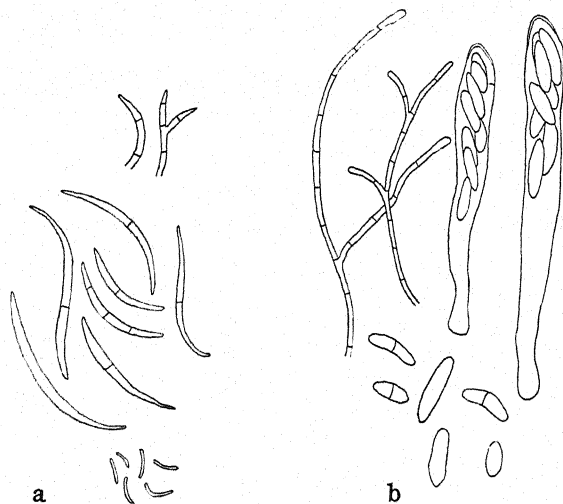


FIG. 1. *Dermatea Peckiana*. a, drawings of conidiophores, conidia, and microconidia; b, asci, ascospores, and paraphyses. $\times 400$.

Conidial stromata erumpent, rounded, verruciform, often somewhat capitate, usually thickly scattered, circular to more or less transversely elongated, 0.5–2 mm. in diameter and up to 1 mm. in height, upper surface uneven and wrinkled around the openings of the cavities, pale yellowish below to black on top, often with a dark vinaceous colour when fresh, leathery to fleshy in consistency, softer than the apothecia; pycnidial cavities numerous in the upper part of the stroma, ovoid, about $100-150 \times 35-100 \mu$, later sometimes becoming more or less confluent and more irregular in shape, opening irregularly and sometimes very widely; conidiophores hyaline, cylindric, septate, sometimes branched, $20-40 \times 2.0-2.5 \mu$, tapering to a slender tip; conidia hyaline, elongated to sub-filiform, sickle shaped or sigmoid, sometimes almost straight, ends pointed

and usually one end more attenuated than the other, one or two celled, $25-60 \times 2.5-4.5 \mu$, emerging in grayish masses which often show also a dark vinaceous colour; microconidia hyaline, filiform, straight or curved, one celled, $8-13 \times 1.5-2 \mu$.

EXSICCATI: Ellis N. Am. Fungi 3042, Type; Fungi Col. 332; Ellis N. Am. Fungi 2170 (*Sphaeronema stellatum*).

SPECIMENS EXAMINED: University of Toronto Herbarium. On *Nemopanthus mucronata*. 4368, 4467, 4468, 4469, 4470, 4471, 6576, 6578, 6592, 7930, 7931, 8438, Temagami Forest Reserve, Ontario—6926, east of Wilcox Lake, Ontario—6933, Bell's Lake, north of Parry Sound, Ontario—7929, Brant Co., Ontario.

On *Ilex verticillata*. 4511, 5071, 7932, 8439, 8444, Temagami Forest Reserve, Ontario—6953, Bell's Lake, north of Parry Sound, Ontario.

University of Michigan Cryptogamic Herbarium. On *Ilex verticillata*. *Micropera caespitosa* (Peck), Ypsilanti, Mich., April 21, 1923. Coll. L. E. Wehmeyer. Det. W. A. Archer.

Cultures were similar from both ascospores and conidia and both produced conidial fructifications in culture. The cultures were similar also, whether isolated from *Nemopanthus* or *Ilex*. On malt extract agar the fungus grew slowly forming colonies which were whitish to pale buff, occasionally with yellowish or brownish tinges, covered with a short, loosely matted, aerial mycelium, which was sometimes more abundant near the centre forming a cottony tuft. The surface of the colony was usually even but was sometimes more or less radially furrowed, especially in Petri dish cultures. In Petri dish cultures the colonies were more heaped up than in tubes where they spread slowly and evenly. Conidial fructifications were formed abundantly as rounded, fleshy stromata, up to 3-4 mm. in diameter and 1-2 mm. in height, externally black or grayish tomentose, and with a very irregular surface. Usually the stroma contained numerous cavities as in nature, but sometimes it was much smaller, cylindric to conic in form, and containing but a single cavity. Sometimes the cavities opened very widely so that the conidiophores appeared to be borne on an exposed surface. The conidia and conidiophores were similar to those found in nature and the characteristic dark vinaceous

colour was quite pronounced in the spore masses and upper part of the stroma. Microconidia were produced abundantly also.

On twigs of *Nemopanthus* and *Ilex* sporulation was rare. Numerous primordia were formed as erumpent, scattered, more or less rounded stromata, whitish to pale yellowish in colour, but usually they continued to develop vegetatively and eventually formed white cottony tufts on the twigs. When spores were produced they were typical of the conidia found in nature, and the characteristic dark vinaceous colour appeared in the spore mass. The spores were produced in cavities in the stroma similar to those found in nature, but usually larger and more irregular in shape. Sometimes tufts of cottony aerial mycelium developed on the twig, particularly around the point of inoculation, but the aerial mycelium did not spread over the whole twig.

The imperfect stage was originally described by Ellis (1876) on *Ilex*, as *Sphaeronema stellatum*. It was said to be similar to *Sphaeronema caespitosum* Peck in habit but to differ in the conidia which were 37.5–50 μ long. Peck (1893) described an imperfect fungus on *Nemopanthus* as *Micropera Nemopanthis* which is evidently the same fungus as *Sphaeronema stellatum* Ellis. Jaczewski (1898) transferred *Sphaeronema stellatum* Ellis to *Micropera*, where it properly belongs. Archer (1926) confused this fungus with *Sphaeronema Peckii* Sacc. & Syd. (*S. caespitosum* Peck) and this will be more fully discussed in connection with the latter species.

The perfect stage was described by Rehm (1915) as *Cenangium Peckianum*. This description was based on the specimen in Ellis N. Am. Fungi 3042 on *Nemopanthus*, which had been labelled *Tympanis Nemopanthis* Peck, but differed from this species in having ellipsoid rather than filiform ascospores. The University of Toronto specimen of Fungi Col. 332 is the same fungus, also distributed under the name of *Tympanis Nemopanthis* Peck.

The genus *Cenangium*, to which Rehm referred the species has been used to include a great number of diverse and unrelated forms. This fungus would belong in the genus *Dermatea*, as typified by *Dermatea Cerasi* (Pers.) Fries. Both of these fungi are found breaking through the bark on twigs of their host, both have black, leathery apothecia and ascospores which are similar in

form, colour, and septation, and both have conidia of similar form. This fungus is, therefore, considered to be a typical *Dermatea* and is transferred to that genus. It is distinct from other species of the genus by reason of its characteristic conidial stage and occurrence on *Nemopanthus* and *Ilex*.

Godroniopsis Nemopanthis sp. nov.

Sphaeronema caespitosum Peck, Ann. Rep. N. Y. St. Mus. 25: 85. 1873.

Sphaeronema Peckii Saccardo and Sydow, Syll. Fung. 14: 900. 1899.

Micropera caespitosa Archer, Ann. Myc. 21: 55. 1926.

Apotheciis erumpentibus, dense gregariis, caespitosis, raro solitariis; caespitibus ad 1 cm. latis, ad 2 mm. altis; apotheciis 0.5–1 mm. diam. subspitatis, primitus globosis, mox urceolatis, dein orbicularibus explanatis,

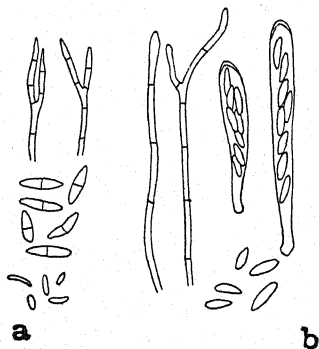


FIG. 2. *Godroniopsis Nemopanthis*. a, drawings of conidiophores, conidia, and microconidia; b, asci, ascospores, and paraphyses. $\times 400$.

rufo-brunneis vel nigris, longitudinaliter striatis, duris, coriaceo-ceraceis, humidis coriaceo-carnosis; hymenio cupuliformiter depresso, dein plano, interdum umbilicato, carnosio, griseo vel roseo tincto; margine tenui subfimbriato, aurantiaco raro rufo-violaceo, in sicco involuto, humido expanso; ascis cylindricis vel cylindrico-clavatis, octosporis $50\text{--}75 \times 5\text{--}8 \mu$; sporis elongato-fusiformibus vel subclavatis, hyalinis, continuis vel uniseptatis, irregulariter distichis vel submonostichis, $10\text{--}12.5 \times 2.5\text{--}4 \mu$; paraphysibus hyalinis, filiformibus, septatis, interdum ramosis, $1.5\text{--}2 \mu$ diam., apice minime incrassatis, epithecium non formantibus.

Apothecia erumpent, thickly scattered, caespitose, occasionally single; the clusters up to 1 cm. in length and 2 mm. in height;

apothecia 0.5–1 mm. in diameter, at first globose, then becoming urceolate, finally spreading out and becoming flat, substipitate, dark reddish-brown to black, longitudinally striate, consistency hard, waxy to leathery, becoming more fleshy-leathery when moist; hymenium circular, at first deeply concave, then plane, sometimes umbilicate, fleshy, grayish to pinkish; margin slightly fimbriate, often rather bright coloured, orange to pinkish or vinaceous, folded inwards when dry, expanding when moist; tissue compact, pseudo-parenchymatous, composed of fairly thick walled, dark coloured, almost isodiametric to slightly elongated cells about 5–15 μ in diameter, arranged in more or less vertically parallel rows which curve obliquely toward the outside where the cells are smaller and darker, the outer cells sometimes growing out into a short hair-like structure of three or four almost globose cells; tissue of the excipulum surrounding the hymenium composed of slender, ascending, parallel hyphae which grow out loosely at the top forming tufts of hyaline hairs projecting over the hymenium; subhymenium a zone of slender, hyaline, rather loosely interwoven hyphae; asci cylindric to cylindric-clavate, eight spored, 50–75 \times 5–8 μ ; ascospores elongate-fusiform to subclavate, hyaline, one or two celled, irregularly biseriate to subuniseriate, 10–12.5 \times 2.5–4 μ ; paraphyses hyaline, filiform, septate, sometimes branched, 1.5–2.0 μ in diameter, the tips not at all or very slightly swollen and not forming an epithecium.

Conidial fruiting bodies erumpent, thickly scattered, caespitose, occasionally single, subulate, tapering from 225–500 μ at the base to 120–225 μ at the tip, up to 2 mm. in length, externally black and smooth; tissue of the basal stroma similar to that of the apothecia, but the walls of the beak composed of three zones, an outer zone of a few rows of almost isodiametric or slightly elongated, very dark walled cells about 8–10 μ in diameter, a middle zone of more elongated, lighter coloured cells, and an inner zone of filamentous, more or less parallel, faintly coloured, abundantly and conspicuously septate hyphae, mostly 3–5 μ in diameter, from which the conidiophores arise as side branches; conidiophores hyaline or pale yellowish, cylindric, tapering to a point, septate, branched, about 25–50 \times 2.5–3 μ , lining the beak and the somewhat elongated-ovoid cavity in the basal stroma; conidia elongate-fusiform, mostly two celled, straight or slightly curved, hyaline or pale yellowish-green, 10–20 \times 2.5–3 μ , emerging in a black mass; microconidia hyaline, one celled, ellipsoid to elongated, 5–10 \times 1.5–2 μ , spore masses pinkish.

TYPE: University of Toronto Herbarium 7950. On *Nemopanthus mucronata*, Bear Island, Temagami Forest Reserve, Aug. 21, 1935. J. W. Groves and J. R. Hansbrough.

EXSICCATI (Conidial stage only): Fungi Col. 4776; Rel. Farl 121.

SPECIMENS EXAMINED: University of Toronto Herbarium. On *Nemopanthus mucronata*. 4359, 4369, 5066, 5944, 5945, 6932, 6948, 6949, 6950, 6951, 6952, 7949, 7950, Temagami Forest Reserve, Ontario.

University of Michigan Cryptogamic Herbarium. On *Ilex verticillata*. *Micropera caespitosa* (Peck), Ypsilanti, Mich., April 21, 1923. Coll. L. E. Wehmeyer. Det. W. A. Archer.

Cultures from ascospores and conidia were similar and both produced the conidial stage in culture. The fungus grew fairly rapidly on malt extract agar, spreading over the medium and forming greenish gray to almost white colonies, "pale smoke gray" to "dark greenish olive." The surface of the colonies was even, covered with a short, downy to velvety, aerial mycelium, sometimes with short, cottony tufts. Conidial fructifications formed abundantly, sometimes remaining as a small, rounded stroma which split open widely, but more often becoming elongated, cylindric-conic, up to 1.5 mm. long and 0.5 mm. in diameter, opening widely at the top, almost black or with a grayish cottony covering. The spore masses were a dark greenish black. Typical conidia and microconidia were produced and the conidia appeared to be formed successively from the same conidiophore, adhering together in chains.

On twigs of *Nemopanthus* the fungus produced a grayish aerial mycelium which was closely appressed to the twig and spread over the surface. Conidial fruiting bodies were formed only occasionally. They arose as an erumpent, rounded stroma which sometimes split open at the top, or more often elongated into a cylindric-conic beak up to 2 mm. in length, black or with a grayish or brownish mycelial covering. The structure was similar to that found in nature but sometimes the tissue was not so compact. The spore masses were characteristically black, and typical conidia and microconidia were produced.

The imperfect stage was originally described on *Ilex* by Peck (1873) as *Sphaeronema caespitosum*. It was said to be remarkable because of its caespitose habit of growth and its black spore

mass, and the spores were described as sub-fusiform, 11–12 μ long. Saccardo and Sydow (1899) pointed out that the name *Sphaeronema caespitosum* had been used previously by Fuckel for a fungus on *Acer*, and that Peck's name was, therefore, invalid. They proposed the new name *Sphaeronema Peckii*.

As found in the field *Sphaeronema Peckii* is quite distinct from *Micropera stellata* by reason of the long beaks on the pycnidia and the black spore masses. The conidia are also much smaller and of a different shape. In the original description of *Sphaeronema stellatum* the fungus was said to resemble *S. caespitosum* Peck in habit, but to differ in the spores. The statement that the two fungi resemble each other in habit was also made in Jaczewski's work which was quoted by Archer (1926). As stated above, the two fungi do not resemble each other in habit in the field, but the long beaks of *Sphaeronema Peckii* are very brittle and in herbarium specimens are usually broken off, and when this occurs the two fungi are not unlike in habit. *Micropera stellata* is essentially a stroma with a thick basal part and numerous cavities in the upper part, while *Sphaeronema Peckii* consists of a basal stroma from which numerous beaked pycnidia arise but with the cavities extending into the basal stroma. Thus when the beaks are broken off it appears to be a stroma with cavities in the upper part as in *Micropera stellata*.

Archer (1926) concluded that *Sphaeronema Peckii* was a young stage of *Micropera stellata* and combined the two forms under the name *Micropera caespitosa*. The specimen from which Archer's cultures were made was kindly loaned to the writer by Dr. Bessie B. Kanouse, and examination of this specimen has shown that while it consists mostly of *Micropera stellata*, on the same twigs there are a few fruiting bodies of *Sphaeronema Peckii* with the beaks broken off. The fungus which Archer examined and figured (1926: TEXT FIG. 13, A, B, C, F) is evidently *Micropera stellata*, but the fungus which he cultured is certainly *Sphaeronema Peckii*. The cultural characters and type of conidial stage produced, as described by Archer, agree with the writer's cultures of *Sphaeronema Peckii* and *Godroniopsis Nemopanthis*, but they are very different from cultures of *Micropera stellata* and *Dermatea Peckiana*. The microconidia in the two forms are strikingly dif-

ferent. In *Dermatea Peckiana* they are filiform and of the type found commonly throughout the genera *Dermatea* and *Pezicula*, but in *Godroniopsis Nemopanthis* they are ellipsoid and of quite a different form, and it is this latter type that Archer obtained in his cultures. Therefore, Archer's conclusion that *Sphaeronema Peckii* was a young stage of *Micropera stellata* is incorrect. The two fungi are quite distinct morphologically and belong to two quite different discomycetes.

The perfect stage is referred to the genus *Godroniopsis* with considerable hesitation. This genus was erected by Diehl and Cash (1929) based on *Peziza querneae* Schw. The genus was characterized as having apothecia which were at first closed, sub-spherical, later cup-shaped to patellate, with a ridged excipulum, and the paraphyses forming an epithecium. A specimen of *Godroniopsis querneae* from the herbarium of L. O. Overholts 16509 was examined. The apothecia of the two species are somewhat similar in gross appearance, shape, and manner of opening, and in both the ascospores are more or less fusiform in shape. However, while the apothecia of *Godroniopsis Nemopanthis* are longitudinally striate, they do not show the prominent excipular ridges of *G. querneae*, they are more waxy in consistency, and the paraphyses do not form an epithecium. In spite of these differences it has been decided to refer the fungus to *Godroniopsis* because it would seem to fit the characters of this genus more closely than of any other, and until more is known of the relationships of these forms it is thought to be unwise to multiply genera.

***Durandiella Nemopanthis* (Peck) comb. nov.**

Tympanis Nemopanthis Peck, Ann. Rep. N. Y. St. Mus. 35: 142. 1884.

Godronia Nemopanthis Sacc., Syll. Fung. 8: 603. 1889.

Apothecia erumpent, scattered, caespitose with up to about twenty-five in a cluster, occasionally single, sessile, slightly narrowed below, up to about 1 mm. in diameter and 1.5 mm. in height, circular to very irregular in shape, closely crowded and often more or less grown together laterally so that it is very difficult to make out the outlines of individual apothecia, dull black externally, consistency hard, horny to cartilaginous, more leathery when moist, hymenium at first concave, becoming plane or convex,

dull black or sometimes shiny black, olivaceous when moist, margin at first raised, black or grayish, later almost disappearing; tissue composed of interwoven hyphae of which the walls are thickened, gelatinized, and grown together, especially at the base and toward the outside of the excipulum where the walls are very dark, but in the central and upper part of the apothecium the tissue may be looser, the hyphae more distinct and the walls not so much grown together; subhymenium a narrow, compact zone of slender, closely interwoven hyphae; asci cylindric to cylindric-clavate, with a slen-

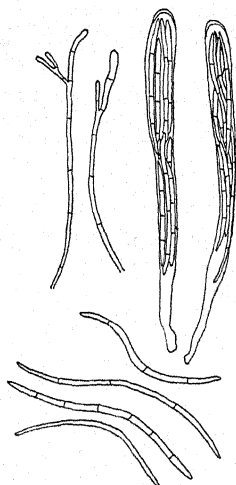
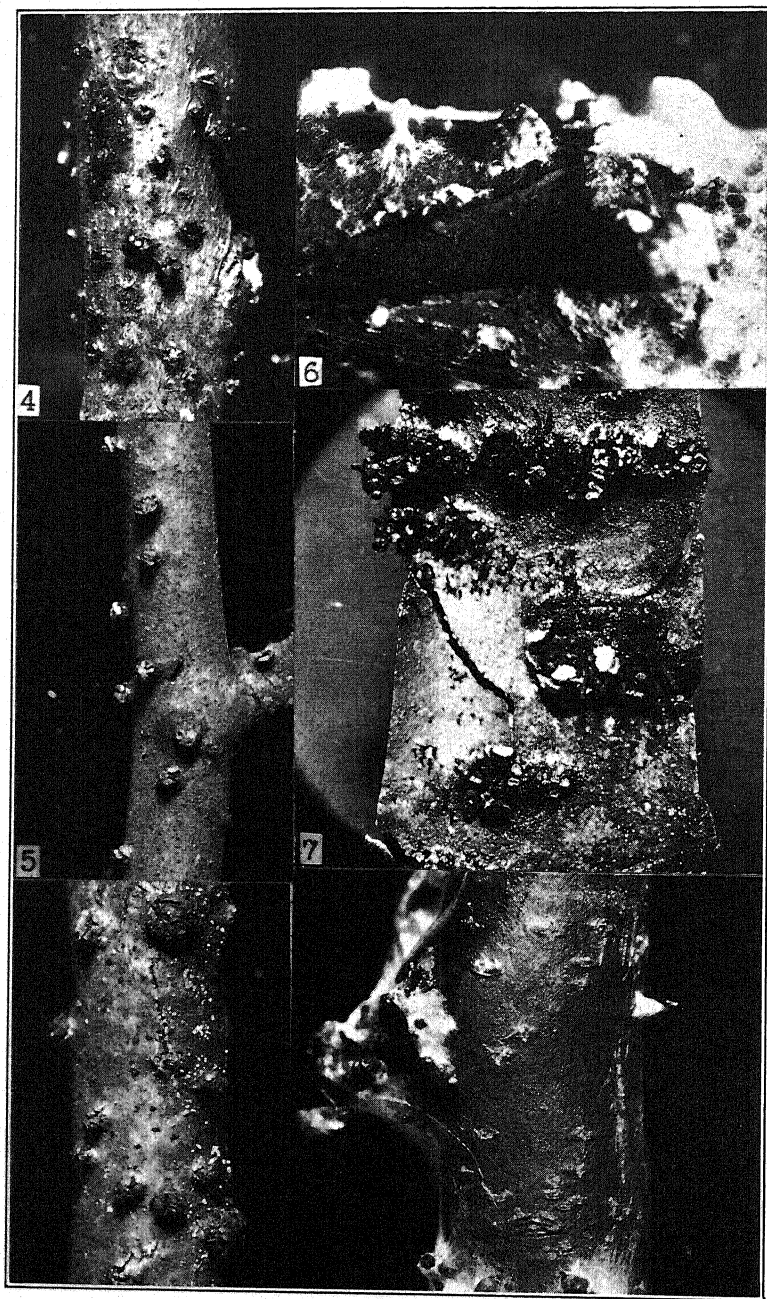


FIG. 3. *Durandiella Nemopanthis*. Drawings of asci, ascospores, and paraphyses. $\times 400$.

der stalk, eight spored, $80-125 \times 7-9 \mu$; ascospores hyaline, filiform, septate, slightly pointed at the ends, almost straight or variously curved, lying parallel or more or less intertwined in the ascus, $50-85 \times 1.5-2 \mu$; paraphyses hyaline, filiform, septate, branched, about $1.5-2 \mu$ in diameter, slightly or not at all swollen at the tips, and forming a yellowish epithecium.

FIGS. 4-9. 4, *Dermatea Peckiana*. Apothecia on a twig of *Ilex*; 5, *D. Peckiana*. Imperfect stage on a twig of *Nemopanthus*; 6, *D. Peckiana*. Imperfect stage on a twig of *Nemopanthus* in culture; 7, *Godroniopsis Nemopanthis*. Apothecia and imperfect stage on a twig of *Nemopanthus*; 8, *G. Nemopanthis*. Imperfect stage on a twig of *Nemopanthus* in culture; 9, *Durandiella Nemopanthis*. Apothecia on a twig of *Nemopanthus*. $\times 4$ approx.



FIGS. 4-9.

EXSICCATI: Ellis N. Am. Fungi 2330; Fungi Col. 4539.

SPECIMENS EXAMINED: Type. Durand Herbarium 3023. On *Nemopanthus canadensis* (*N. mucronata*), Grafton, Reno Co., N. Y. Coll. Dr. Peck.

University of Toronto Herbarium. On *Nemopanthus mucronata*. 3515, 5067, 5068, 6567, 6583, 7940, Temagami Forest Reserve, Ontario—4840, Ottawa, Ontario—6936, Bell's Lake, north of Parry Sound, Ontario—7941, south of Hatchley, Ontario.

Farlow Herbarium, Harvard University. On *Nemopanthus canadensis*, Fort Ethan Allen, Vt., Coll. E. A. Burt, July 1896. Det. Peck. Ex. Burt Herbarium.

On malt extract agar the colonies from ascospores grew slowly forming greenish-gray to yellowish or sometimes brownish colonies. The margin was even and almost colourless and the rest of the colony was covered with a short, even, velvety, aerial mycelium, the surface appearing smooth. Sometimes more or less unevenly rounded to columnar stromatic structures developed which might be up to 5 mm. in diameter and 2 mm. in height. Colourless or amber drops of liquid appeared on them and they later developed flat, black, disc-like areas on the top and sides. The tissue resembled somewhat the basal part of the apothecial stroma in structure but no spores of any kind have been produced.

On twigs of *Nemopanthus* the fungus produced a velvety, gray, aerial mycelium which was closely appressed to the twig and most abundant near the point of inoculation but sometimes spread over the whole twig. No fruiting bodies of any kind have been produced.

Careful search in the field has failed to reveal any conidial stage associated with the apothecia.

This fungus was originally described on *Nemopanthus* by Peck (1882) as *Tympanis Nemopanthis*, and later transferred to *Godronia* by Saccardo (1889) because of the filiform ascospores. Rehm (1913) erected the genus *Durandia*, based on *Tympanis Fraxini* (Schw.) Fries and the genus was characterized as having apothecia like a *Tympanis* and ascospores like a *Godronia*. This fungus on *Nemopanthus* would seem to be congeneric with *Durandia Fraxini* (Schw.) Rehm.

Von Höhnelt (1918) pointed out that the name *Durandia* was invalid, having been used previously for a genus of flowering plants. He was of the opinion that *Tympanis Fraxini* belonged in *Godronia*, largely because of the character of the imperfect stage and the filiform ascospores. Nannfeldt (1932) accepted Von Höhnelt's interpretation and included *Durandia* Rehm and *Godronia* Moug. as synonyms of *Scleroderris* Fries. Seaver (1932) proposed the new name *Durandiella* to replace the invalid name *Durandia*.

The writer, as a result of his studies in this group, is of the opinion that a separation between the black, patellate forms and the urceolate forms having filiform ascospores is desirable, and that, therefore, *Durandiella* Seaver should be recognized as distinct from *Scleroderris* or *Godronia*.

SUMMARY

Three species of discomycetes of the family Dermateaceae have been distinguished on *Nemopanthus* and their conidial relations established by cultures.

1. *Dermatea Peckiana* (Peck) Groves of which the imperfect stage is *Micropera stellata* (Ellis) Jaczewski.
2. *Godroniopsis Nemopanthis* Groves of which the imperfect stage is *Sphaeronema Peckii* Saccardo and Sydow.
3. *Durandiella Nemopanthis* (Peck) Groves of which no imperfect stage has been found.

UNIVERSITY OF TORONTO

LITERATURE CITED

- Archer, W. A. Morphological characters of some Sphaeropsidales in culture. *Ann. Myc.* 24: 1-84. 1926.
- Diehl, W. W. & Cash, Edith K. The taxonomy of *Peziza quernei*. *Mycologia* 21: 243-248. 1929.
- Ellis, J. B. South Jersey fungi. *Bull. Torrey Club* 6: 106-109. 1876.
- Höhnelt, F. v. Fragmente zur Mykologie. No. 1103. Über *Peziza Fraxini* Schw. *Sitzb. Akad. Wiss. Wien* 127: 566-567. 1918.
- Jaczewski, A. Monographie du genre *Sphaeronema* Fr. *Nouv. Mem. Soc. Imp. Nat. Moscou* 15: 277-386. 1898.

- Nannfeldt, J. A.** Studien über die Morphologie und Systematik der nicht-lichenisierten inoperculaten Discomyceten. Nova Acta Soc. Sci. Upsal. IV, 8²⁰: 1-368 pp. 1932.
- Peck, C. H.** Ann. Rep. N. Y. State Mus. 25: 57-124. 1873.
——. Ann. Rep. N. Y. State Mus. 35: 125-164. 1884.
——. Ann. Rep. N. Y. State Mus. 46: 83-149. 1893.
- Rehm, H.** Ascomycetes exs. Fasc. 52. Ann. Myc. 11: 166-171. 1913.
——. Ascomycetes novi. Ann. Myc. 13: 1-6. 1915.
- Saccardo, P. A.** Sylloge Fungorum 3: 1-860. 1884.
——. Sylloge Fungorum 8: 1-1143. 1889.
—— & **Sydow, P.** Sylloge Fungorum 14: 1-1273. 1899.
- Seaver, F. J.** The genera of fungi. Mycologia 23: 248-263. 1932.

A NEW SPECIES OF PHIALEA ON ALDER SEEDS

J. R. KIENHOLZ AND EDITH K. CASH ¹

(WITH 4 FIGURES)

Two interesting Discomycetes were collected in the spring of 1932 in the Hood River Valley, Oregon, under alder trees. Little difference was apparent when they were observed superficially, but closer examination revealed that their seat of origin was entirely distinct. The one, arising from alder catkins, was kindly identified by H. H. Whetzel and F. J. Seaver as *Ciboria amentacea* (Balb.) Fuckel. The second, developing from overwintering seeds of the same host, appears to be undescribed and will be dealt with here.

Collections of this fungus have been made each year since its discovery. It has usually been found associated with the species of *Ciboria* referred to and so far only on seeds of *Alnus oregana* Nuttall. An extensive survey has not been made but the fungus appears to be common throughout the Hood River Valley, Oregon, at elevations ranging from 100 to 3000 feet. It matures at the time when alder catkins begin shedding pollen and disappears in a short time. Occasionally numerous apothecia have been found developing from infected seeds still held within the cones (FIG. 1). Both fungi were scarce during the spring of 1936, probably due to an unusually dry summer season in 1935, followed by early freezing weather.

The genera *Alnus* and *Salix* are hosts for several species of *Phialea*. Comparisons of available specimens and published descriptions, however, have failed to reveal a species to which our fungus can be referred. *Phialea alniella* (Nyl.) Sacc., *P. amenti* (Batsch.) Quél., and *P. viridifusca* (Fuckel) Sacc. appear to be

¹ Junior Pathologist and Assistant Mycologist, respectively, Divisions of Fruit and Vegetable Crops and Diseases and Mycology and Disease Survey, Bureau of Plant Industry, U. S. Department of Agriculture, Hood River, Oregon, and Washington, D. C.

its closest relatives, all of which occur on catkins. The larger size of the apothecia and their development from alder seeds are macroscopic characters which easily distinguish our fungus from them. The longer and wider asci and ascospores, and certain other features described below, serve further to separate this species of *Phialea* from others occurring on *Alnus* or related plants. The species name *seminicola* has been selected as being descriptive of the seed-inhabiting character of this new species.

Phialea seminicola sp. nov.

Apothecia stipitate, waxy-membranous, single or 2-5 arising from a seed, cupulate with inrolled margin, finally expanded and often flattened above, up to 6 mm. diam., commonly Tilleul-buff to avellaneous, hymenium fawn-color or somewhat variable, paler when old or dry; hypothecium composed of loosely arranged, irregularly elongated, pale brown cells; excipular cells several layers thick, thin-walled, pale brown, irregularly spheroid, up to 25 μ diam., merging into the elongated cells of the stem; stem up to 10 mm. long, usually less, 0.5-0.8 mm. diam., sometimes swollen and hairy toward the base when young, becoming even and often darker when older; asci clavate, thick-walled at apex, short-pedicellate, $75-130 \times 7.5-12.5 \mu$ (mean $104 \times 9.9 \mu$), uncolored by iodine; paraphyses granulate, filiform, simple or branched below the middle, slightly enlarged up to 4 μ at apex, hyaline; spores unicellular, fusoid-ellipsoid with somewhat pointed ends, containing 1-several small guttules toward each end, hyaline, $12-20 \times 3.5-5 \mu$ (mean $15.8 \times 4.9 \mu$), 1- or irregularly 2-seriate.

Ascomatibus stipitatis, ceraceo-membranaceis, avellaneis, 1-5 ex quoque semine oriundis, cupulatis margine incurvato, dein applanatis, usque ad 6 mm. diam., hypothecio prosenchymatico, ex cellulis elongatis, fuscidulis, laxe intertextis, excipulo ex stratis nonnullis cellularum subglobosarum tenellarum compositis; stipite usque ad 10 mm. longo, .5-.8 mm. diam., pruinoso vel glabro; ascis clavatis, apice crasse tunicatis, breve pedicellatis, $75-130 \times 7.5-12.5 \mu$; paraphysibus filiformibus, hyalinis, granulosis, apice 4 μ diam.; sporis unicellularibus, fusoido-ellipsoideis, ad extremitates guttulis, hyalinis, $12-20 \times 3.5-5 \mu$, 1-2-seriatis.

In seminibus *Alni oregonae*, in vere, Hood River, Oregon.

FIG. 1, apothecia $\times 1$; 2, apothecia $\times 15$, showing pubescent stipe; 3, camera lucida drawing of a portion of an apothecium showing structural characters; 4, camera lucida drawings of asci, ascospores, and paraphyses. (Photographs and drawings by J. R. Kienholz.)

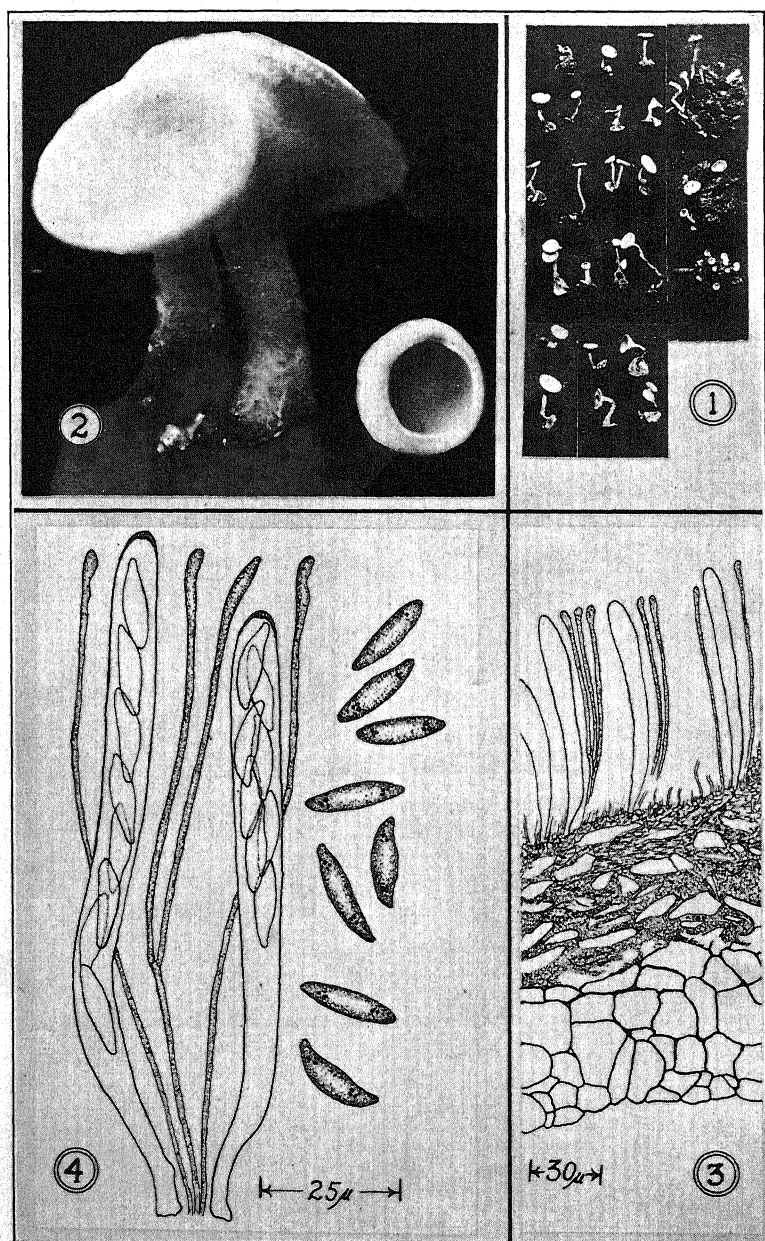


FIG. 1-4.

Developing from alder (*Alnus oregona* Nuttall) seeds, Hood River, Oregon, in early spring, coll. J. R. Kienholz, 1932-1936. Type *K 10*, February, 1935.

Type specimens have been deposited in the Mycological Collections of the Bureau of Plant Industry, U. S. Department of Agriculture, and Department of Botany, Oregon State College, Corvallis, Oregon. Collections from the type locality have also been distributed to the Mycological Herbaria of the following institutions: New York Botanical Garden, Cornell University, University of Michigan, and Washington State College.

BUREAU OF PLANT INDUSTRY

NATURE OF VARIATION IN *HELMINTHOSPORIUM SATIVUM*¹

J. J. CHRISTENSEN AND F. R. DAVIES²

(WITH 3 FIGURES)

INTRODUCTION

Most species of *Helminthosporium* that have been carefully investigated comprise numerous races differing in parasitic capabilities, cultural characters, and to some extent in morphology. This is particularly true of *Helminthosporium sativum* P.K.B., in which new races frequently arise as sectors in cultures on artificial media. The mechanism by which these variants arise is not definitely known, but it is usually attributed to mutation.

Genetic changes in fungi may result from hybridization and subsequent segregation, by mutation or saltation, and possibly as a result of heterocaryosis. Although hybridization is very common in some fungi and results in the production of new types, it apparently does not play an important rôle in *Helminthosporium sativum*, the perfect stage of which has been described as *Ophiobolus sativus* (P.K.B.) Ito and Kuribayaski (10). Since 1920 the authors have made numerous attempts to induce the formation of the sexual stage, but without success. Mutation, as a mechanism for the production of new races, has been demonstrated in fungi, particularly in haploid lines of smut fungi. Mutation in *Helminthosporium* spp. also has been frequently reported, but some investigators have objected to the term chiefly because the cells of the hyphae, conidia, and germ tubes are usually multinucleate. The variants then might be due to the separation or reassortment of nuclei.

¹ Paper No. 1438 of the Scientific Journal Series of the Minnesota Agricultural Experiment Station. The investigations were supported in part by a grant from the Graduate School of the University of Minnesota.

² The writers are greatly indebted to Professor E. C. Stakman for his criticism and help in the preparation of the manuscript.

Recent work by Hansen and Smith (8), Graham (6), and Shands and Dickson (12) has suggested that heterocaryosis may be rather common in the Fungi Imperfecti and hence may account for many of the variants that arise so abundantly in culture. More recently Hansen (7) has reported heterocaryosis in isolates representing twenty-eight strains, twelve species, and seven genera in three orders of the Fungi Imperfecti. Leonian (11) attempted to produce a mixochimaera in *Fusarium moniliforme* Shel. in culture but was unsuccessful. From his studies on the nature of variation in certain species of *Fusarium* and *Helminthosporium*, Dickinson (4) concluded that the variants were not due to heterocaryosis or to cytoplasmic inheritance but rather to saltation. However, he did find that hyphal cells of different strains of *Fusarium* sp. would fuse, and in three cases both of the original strains were isolated from cultures resulting from hyphae growing out from the fused cells. This indicates that nuclei of the two strains were temporarily associated in the hyphal cells but that they soon separated again.

The present investigation was undertaken in an attempt to elucidate the nature of the variation that occurs so commonly in *Helminthosporium sativum* and certain other dark-spored species of this genus. Particularly, the writers attempted to ascertain if there was a tendency for two genetically different nuclei to become associated in the vegetative stage and for this association to persist through the conidia. A preliminary paper on this work has been published (3).

EXPERIMENTAL METHODS

Hyphal anastomosis.

Many workers have observed hyphal fusions between different races within species of Fungi Imperfecti, and Dickinson (4) observed fusions between different species of *Helminthosporium*. Obviously, the occurrence and extent of hyphal anastomosis is of primary importance in a study of heterocaryosis. The writers therefore studied fusions between hyphae of the same species and between those of different dark-spored species of *Helminthosporium*. In all, fusion tests were made between thirteen different combinations, involving seven races and four variants of *Helmin-*

thosporium sativum, two races of *Helminthosporium N* (see Henry (9)), and one race of *H. tetramera* McKinney.

The tests were made in three ways: (1) by mixing conidia and mycelia on glass slides smeared with nutrient agar and then incubating for one to two days in a moist chamber; (2) by planting

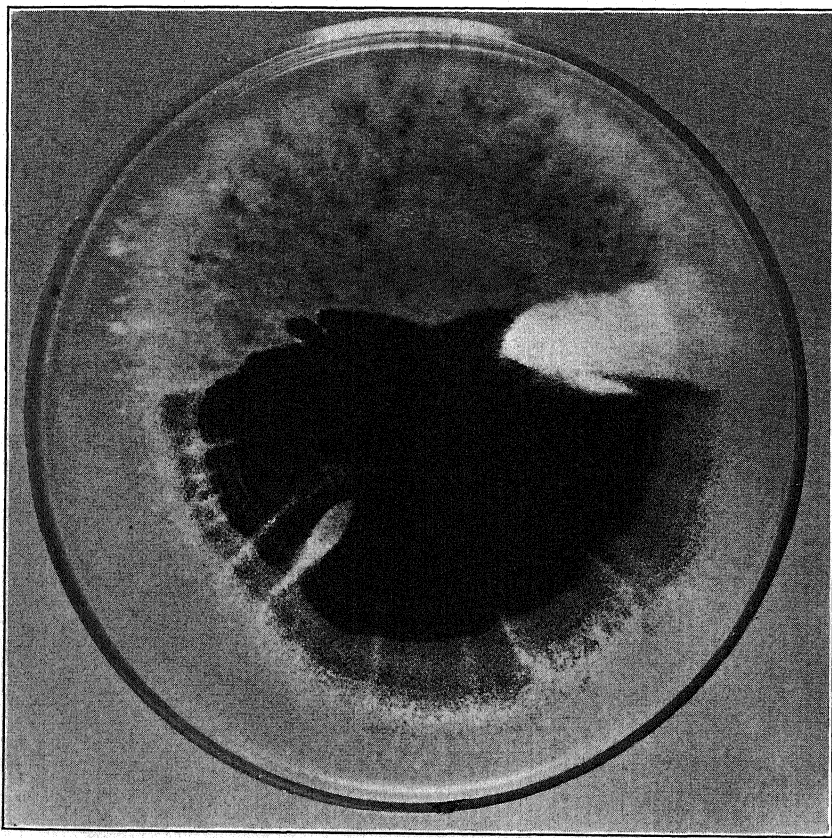


FIG. 1. *Helminthosporium sativum* race 1 giving rise to variants on bacterial-staled medium. Race 1 has been cultured for 17 years, transferred several hundred times, and single spored four successive times.

a mixture of spores on agar drops on cover slips; and (3) by planting spores of two races on separate agar drops placed about 5 mm. apart on cover slips and observing the hyphal fusions on the plain glass between the drops. In some cases the process of fusion was observed more or less continuously for periods up to

one hour, whereas many were only observed after the fusion had taken place.

Within the same species of *Helminthosporium* fusions usually were abundant, but between species true fusions (cell walls completely broken down) were rarely observed. However, pseudo fusions (hyphal union, but cell walls not broken down) designated by Buller (1) as "hyphal adhesion" between species of *Helminthosporium* were very common. In fact, in several tests this type of fusion was so abundant between *H. sativum* and a small-spored species (*Brachysporium* type, race 8) and also between *H. sativum* and *Helminthosporium* N race 3 that the hyphae of the two species appeared to be united to form a network.

The origin of the nuclei in conidia of *Helminthosporium* is of considerable importance in a study of variation. Several investigators have noted that conidia, hyphal cells, and germ tubes of *Helminthosporium* spp. are usually multinucleate (4, 6). Nuclear stains were made of *Helminthosporium sativum*, *Helminthosporium* N, *H. tetramera*, and a *Brachysporium* type, using the ordinary cytological technic. The spores were germinated on glass slides, incubated for one to two days, then fixed in weak chromo-acetic, and stained with Haidenhain's iron-alum haematoxylin. In the four species studied the number of nuclei in the hyphal cells varied from one to six, one and two being the most common. Germ tubes were always multinucleate, probably due to a more rapid nuclear division than cell wall formation. Young branches from the older hyphae and young conidiophores often contained a single nucleus, which supports Dickinson's observations (4). If this is true, all nuclei in the spores produced on the same conidiophore are derivatives of a single nucleus and should therefore be of the same genotype, assuming normal mitosis. Graham (6), on the other hand, obtained indications that the nuclei in conidia of *H. gramineum* Rab. (a light-spored type) were not derived from a single nucleus, and Hansen and Smith (8) concluded that conidia of *Botrytis cinerea* Pers. may contain genetically different nuclei.

Hyphal-tip cultures.

Eide (5) and Ullstrup (14) found that hyphal-tip cultures from the same germinating ascospore or conidium of *Gibberella Saubi-*

netii (Mont.) Sacc. were always alike. Shands and Dickson (12), however, found that hyphal-tip isolates of *Helminthosporium gramineum* from the same germinating conidium might differ in cultural and parasitic behavior. In order to obtain evidence by cultural methods regarding the possible heterocaryotic condition of conidia of *H. sativum*, single spores from mixed races growing in combination and also from sectoring cultures were germinated

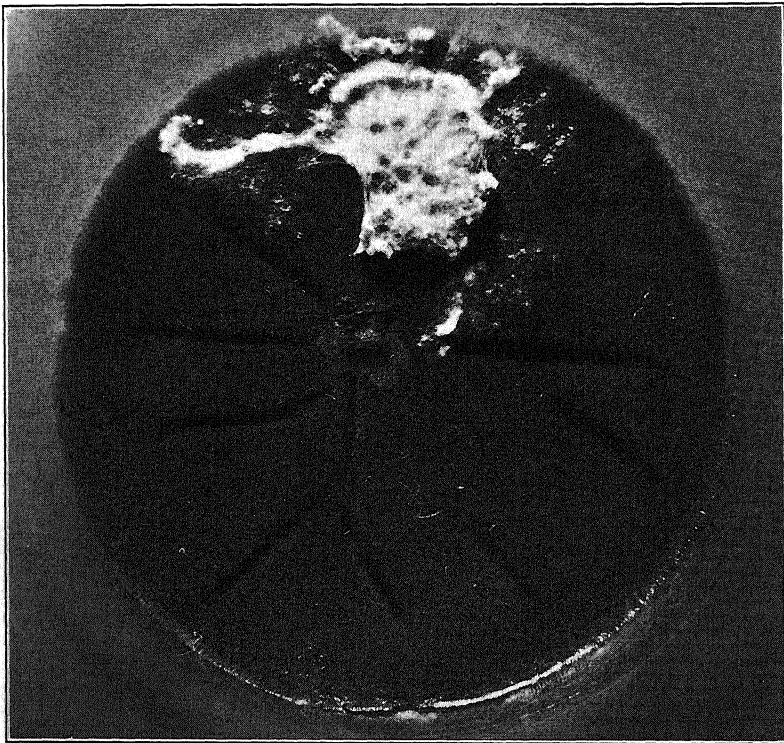


FIG. 2. *Helminthosporium N* race 3 giving rise to a "patch" variant.

on agar drops from which one to four hyphal tips were isolated. The tips usually were cut from a germ tube after it had produced two or three short branches, although some were cut off before the branches developed. Many of the hyphal tips consisting of a single cell died; but they grew well if they consisted of two or more cells. In each case the germinating spore (spore and the basal cells from which the hyphal tips had been cut) also was isolated.

In all, 207 hyphal-tip isolates were made from 103 germinating conidia. In one series, 41 conidia were selected from sectoring monosporous cultures of five distinctly different races of *Helminthosporium sativum* (FIG. 1). If variation in this series were due to heterocaryosis, conidia selected from the parental part of the colonies should contain genetically different nuclei, and there would be a likelihood that hyphal tips from the same conidium might be different because of the chance assortment of nuclei. With one possible exception, however, all the isolates (including hyphal tips and the spore and its basal cells from which the hyphal tips had been cut) from the same conidium were identical. In preliminary tests, one hyphal-tip isolate was distinctly different from the other hyphal-tip cultures from the same germinating conidium. Examination of the test-tube culture showed the presence of two kinds of growth, one true to type, the other apparently similar to a variant commonly produced in the parental culture; hence the variant probably arose in the test-tube culture as a mutation rather than as a result of dissociation of nuclei in the germ tube.

Another series of 141 hyphal tips, also included in table 1, was cut from 62 germinating conidia obtained from mixtures of dis-

TABLE 1
SUMMARY OF HYPHAL-TIP ISOLATIONS FROM GERMINATING CONIDIA OF
HELMINTHOSPORIUM SATIVUM

| Source and race or variant of <i>H. sativum</i> | Number of conidia | Number of hyphal tips per conidium isolated | | | | Total number of iso- lates ^a |
|-------------------------------------------------------|-------------------------|------------------------------------------------|----|----|----|--------------------------------------------------|
| | | 1 | 2 | 3 | 4 | |
| Sectoring monosporous cultures | | | | | | |
| 1 | 9 | 2 | 5 | 2 | 0 | 18 |
| 16 | 2 | 2 | 0 | 0 | 0 | 2 |
| 31 | 9 | 2 | 4 | 3 | 0 | 19 |
| 32 | 12 | 4 | 4 | 4 | 0 | 24 |
| 33 | 9 | 9 | 0 | 0 | 0 | 9 |
| Mixture of two races or variants on agar drops | | | | | | |
| 1 and 32 | 32 | 13 | 10 | 5 | 4 | 64 |
| 1 and 1-3 ^b | 8 | 2 | 2 | 2 | 2 | 20 |
| 40 and 1-4 | 22 | 7 | 5 | 6 | 4 | 51 |
| Totals | 103 | 41 | 30 | 22 | 10 | 207 |

^a In each case the germinating spore (spore and the basal cells from which the hyphal tips had been cut) was isolated also.

^b Variants are indicated by a (-) sign following the race number.

tinct races or variants of *Helminthosporium sativum* growing on agar drops. Three different mixtures of races of *H. sativum* were made. Without exception the isolates, including the germinating spore with its basal cells and the hyphal tips derived from it, were identical.

Conidiophore progenies.

Having found no definite evidence for differences in any of the hyphal-tip isolates arising from single spores, it was considered possible that only a single nucleus passes into each spore, so that all nuclei in a spore would be genetically alike, assuming normal mitosis. Therefore, it seemed advisable to analyze the conidial progenies of individual conidiophores.

Conidia from individual conidiophores were taken from colonies arising from barley seed, either naturally or artificially inoculated with many races and species of *Helminthosporium* or from a mixed growth of two distinct races or species on agar drops. Comparisons of the progeny from the same conidiophore were made on potato-dextrose agar, first in a preliminary way in test tubes and then in petri dishes. Table 2 lists the isolations from naturally

TABLE 2
SUMMARY OF CONIDIAL ISOLATIONS FROM INDIVIDUAL CONIDIOPHORES OF CULTURES OBTAINED FROM INFECTED SEED

| Source of barley seed | Number of conidiophores | Number of spores per conidiophore isolated | | | | Number of isolates |
|----------------------------------------------------------|-------------------------|--------------------------------------------|----|----|-----------|--------------------|
| | | 2 | 3 | 4 | 5 or more | |
| Naturally infected..... | 29 | 29 | 0 | 0 | 0 | 58 |
| Artificially inoculated with a combination of races..... | 69 | 32 | 14 | 14 | 9 | 208 |
| Total..... | 98 | 61 | 14 | 14 | 9 | 266 |

and artificially infected barley seed. A total of 266 conidia were isolated; 58 from naturally infected seed and 208 from artificially infected seed representing progenies from 98 conidiophores. In most cases isolations were made as soon as sporulation started, so that if a heterocaryotic condition existed the chances for migration of different kinds of nuclei into different conidiophores might be greater in the earlier stages of growth, especially if the nuclear

associations were only temporary. With two exceptions, no variations were observed between cultures from conidia produced on the same conidiophore. The two variant cultures differed very slightly but consistently from other isolates from the same conidiophore. Several single spores were isolated from one of these variants, and still other variants arose in the cultures.

The races and variants used in combination cultures were selected because of easily recognizable contrasting characters. It is rather significant that the 258 monosporous isolates from 107 conidiophores selected from 10 different combinations of races were not affected by the association and also that single-spore cultures from the same conidiophore were without exception identical (Table 3). Furthermore, 260 conidia were selected at ran-

TABLE 3
MONOSPOROUS ISOLATIONS FROM INDIVIDUAL CONIDIOPHORES FROM
COMBINATIONS OF RACES OF *HELMINTHOSPORIUM* SPP.
GROWN ON AGAR DROPS

| Race and species of <i>Helminthosporium</i> | Number of conidio- phores | Number of spores per conidiophore isolated | | | | Number of isolates |
|------------------------------------------------|------------------------------------|-----------------------------------------------|----|---|-----------|--------------------------|
| | | 2 | 3 | 4 | 5 or more | |
| <i>H. sativum</i> | | | | | | |
| 1 and 40-1..... | 17 | 10 | 6 | 1 | — | 42 |
| 1 and 32..... | 12 | 12 | — | — | — | 24 |
| 1 and 33..... | 1 | 1 | — | — | — | 2 |
| 40-1 and 1-1-1-4... | 9 | 9 | — | — | — | 18 |
| 40-1 and 14..... | 4 | 4 | — | — | — | 8 |
| 40-1 and 15..... | 12 | 12 | — | — | — | 24 |
| 31 and 32..... | 18 | 12 | 4 | 1 | 1 | 45 |
| 32 and 33..... | 2 | 2 | — | — | — | 4 |
| 14 and 1-3..... | 23 | 23 | — | — | — | 46 |
| <i>Helminthosporium N</i> | | | | | | |
| 1 and 3..... | 9 | 0 | 2 | 3 | 4 | 45 |
| Total..... | 107 | 85 | 12 | 5 | 5 | 258 |

dom from five different combinations of races on agar drops, and in all cases only the parental cultures were reisolated. Moreover, numerous conidiophores from various sources were cultured, and in every case they were identical to the conidial progeny isolated from them. This indicates that the nuclear condition in the conidia was the same as in the conidiophores.

Variations.

Although all hyphal-tip progenies from the same germinating conidium and virtually all conidial progenies from the same conidiophore were identical culturally, under certain conditions most of them sectorized and gave rise to many variants. Variants arose either in patches or fan shaped sectors. A "patch" variant may arise in young or in older cultures; it may remain small, tufted, or blotch like, or it may grow over the entire surface of the parent colony. Figure 2 shows a "patch" variant in *Helminthosporium* N race 3. Such variants are likely to be overlooked, especially when they occur in test-tube cultures, and thus may account for many unstable cultures.

Some of the hyphal-tip or conidial isolates occasionally gave rise to distinct sectors, indicating their potential ability to produce variants. Obviously, the extent and frequency of the variation in isolates obtained in these studies are highly significant. It is well known that environmental factors have a marked effect on the frequency of variation in fungi. In order to induce variation many different substances were added to nutrient media, but none proved entirely satisfactory. Recently, it was found that the addition of 50 to 100 cc. of a certain dead bacterial culture to one liter of ordinary potato-dextrose agar increased the frequency and also the kind of variations produced.³ On this bacterial-staled medium most of the isolates of *Helminthosporium sativum* developed from 2 to 5 variants per colony and some produced many more, 10 to 20 per colony being not uncommon. For instance, duplicate colonies from 10 hyphal-tip cultures isolated from 5 different germinating conidia of a mixed culture (races 1 and 32) gave rise to more than 300 sectors, an average of 15 per plate. In similar tests 60 monosporous isolates gave rise to 193 variants. Race 1 deserves particular mention, for it has been in culture for 17 years, transferred several hundred times, and single spored four successive times. As far as can be ascertained, it is identical with the original isolate in cultural characters and in parasitic capabilities. Furthermore, in 1925 (see (2), plate 9) and on several occasions in recent years numerous single spores

³ This work will be reported in detail at a later date.

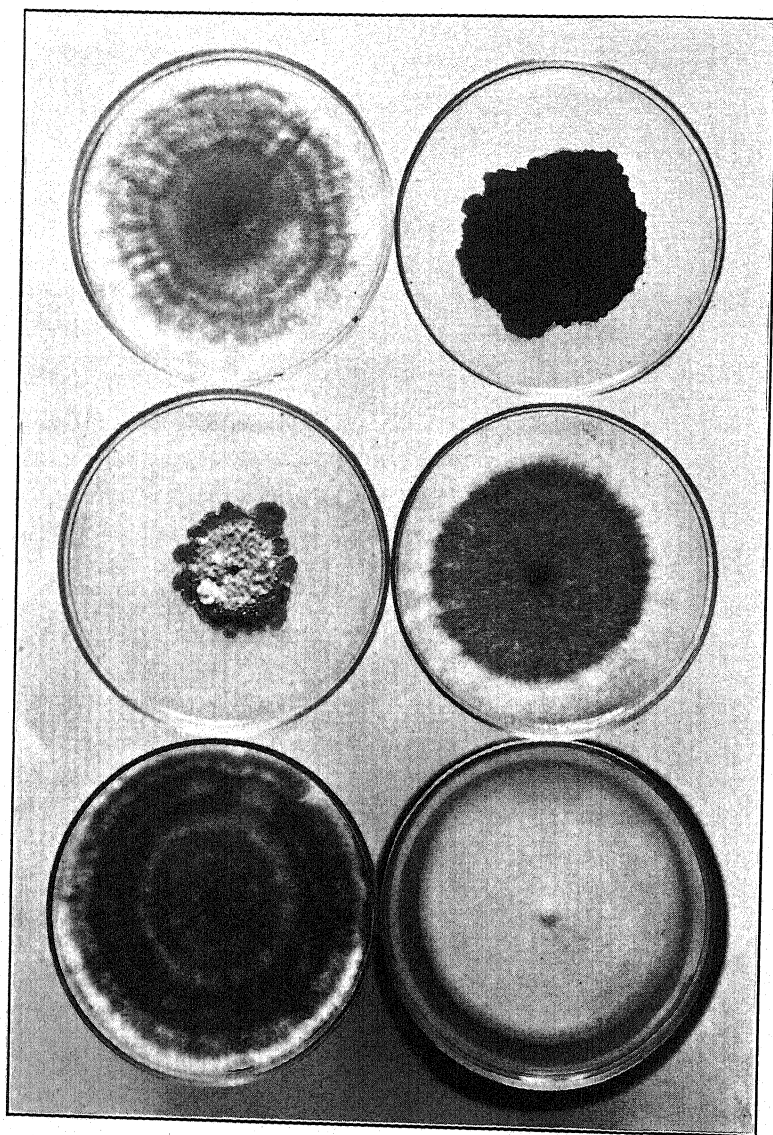


FIG. 3. Parent (lower left) and five variants of *Helminthosporium sativum*. The parent had been cultured for 17 years, and the variants appeared in cultures on bacterial-staled agar.

were selected at random from it, but in all cases the monosporous isolates and the parental culture were identical. However, race 1 has occasionally produced variants in the form of sectors, but even more important is the fact that it still gives rise to variants, especially when grown on the bacterial-staled nutrient medium (FIG. 1 and 3). For instance, within the last year at least 26 distinct variants have been isolated from it, many of which sectorized again. In a preliminary test quadruplicate colonies developed 20 distinct sectors, and 4 other colonies growing on a somewhat greater concentration of the staled medium developed so many sectors and "patch" variants that their identity and number could not be definitely ascertained, while the 4 control colonies on standard potato-dextrose agar did not sector. In later tests, involving 17 colonies on the bacterial-staled medium, 81 variants occurred representing many distinct types. It is significant that one or more variants arose in nearly every colony on staled medium, while there were none in 17 control colonies on standard potato-dextrose agar.

These results indicate further that variation at least in certain races of *Helminthosporium sativum* can be induced by certain environmental factors and is probably due primarily to changes within the nucleus, rather than to heterocaryosis.

DISCUSSION

Hyphal-tip and monosporous cultures of *Helminthosporium sativum* produced numerous variants of different kinds, but the nature of this variation is not definitely known. Anastomosis between hyphal cells of different races was very common, and it is reasonable to assume that there was a certain amount of mixing of cytoplasm and nuclei. However, no immediate growth expression of the mixture of two races was observed, and if intermixing of nuclei occurred there was no indication that the association of nuclei was perpetuated through the spore to dissociate at a later time. Monosporous isolates taken from agar drops or host tissue inoculated with two races or species of *Helminthosporium* were, with three exceptions, always identical to one or the other of the parents, and new or intermediate types were never observed. Subsequent single-spore isolation from the three exceptions did not

result in isolates identical to either of the original components; hence they probably arose in the test tubes as "patch" variants, which is not uncommon in certain races of *Helminthosporium*. Other possibilities are that the change may have occurred in either the conidiophore or in the conidium.

In some fungi following hyphal fusion with subsequent intermingling of nuclei between two races, there is often a marked growth response in culture and often a pronounced change in parasitism. However, in several hundred tests with *Helminthosporium sativum* no variation in growth character was observed when colonies of different races were grown side by side in a petri dish.

In cultures of certain heterothallic and homothallic fungi whose hyphal cells are dicaryotic or multinucleate there may arise unisexual conidia or areas of unisexual mycelium, indicating that the conjugate nuclei may sometimes separate. Presumably nuclei that are not held together by sexual attraction would separate more easily than those that are. As there is no evidence that the nuclei in the cells of *Helminthosporium* are bound by sexual attraction, it would be expected that they would separate more readily than those of dicaryons. If, then, the nuclei in cells of *Helminthosporium sativum* are genetically different, one would expect that there might occasionally be a chance assortment in the different germ tubes from a single conidium, and cultures resulting from the different hyphal tips should be different. But analysis of progenies from individual conidiophores and of hyphal tips from germinating conidia indicates that nuclear changes or dissociations rarely occur in conidiophores even when taken from mixed cultures of two races. Conidia and germ tubes of many fungi including *H. sativum* are multinucleate, but this is no guarantee that they contain genetically different nuclei, since all the nuclei may be derivatives of the same nucleus. Cytological studies indicate that most young conidiophores of *H. sativum* are uninucleate; hence nuclei in the conidia produced on them are derived from the same nucleus. Extensive cultural studies of progenies of conidiophores support this statement.

Stakman and his co-workers have shown that variations are common in haploid lines of smut fungi. These lines originated

from single uninucleate sporidia, yet a single line of *Ustilago Zeae* (Beck.) Ung. gave rise to more than 150 different cultural types of variants (13). If mutation occurs in some fungi, there can be no valid reason why it should not occur in *Helminthosporium sativum*. In the present studies there was no indication that the growing together of two or more races of *H. sativum*, either on agar or in the host, stimulated the production of variants. Isolates from mixed cultures sectored no more frequently than the original races, some of which had been in culture for many years. In fact, one race had been cultured for 17 years, during which time it had been single spored four times, yet it still gives rise to numerous variants of different types.

Heterocaryosis, in the sense of a heterothallic fungus containing two kinds of genetically different nuclei, is a common phenomenon in both Ascomycetes and Basidiomycetes. It has been shown that such fungi may give rise to three very distinct types, i.e., two different haploid strains and a dicaryotic strain. By analogy, it seems reasonable to assume that certain members of the Fungi Imperfecti may also produce three different strains. Although the evidence presented strongly indicates that the variation encountered in *Helminthosporium sativum* is due primarily to mutation (gene change or chromosomal aberration), the possibility of heterocaryosis is not excluded. Heterocaryosis may be a common cause of variation in certain other species of *Helminthosporium* and also in other fungi, but it is not considered an important cause of variation in *H. sativum*.

SUMMARY

1. The conidia and germ tubes of *Helminthosporium sativum* are multinucleate, whereas hyphal cells are uninucleate to multinucleate, and young conidiophores are usually uninucleate. All nuclei in the conidia produced on the same conidiophore are perhaps derivatives of a single nucleus and hence genetically alike.

2. True hyphal fusion between races of *H. sativum* is common but rare between *H. sativum* and other dark-spored species. However, pseudo-hyphal fusion between species of *Helminthosporium* is not uncommon.

3. Cultural comparisons were made of 207 hyphal-tip isolates obtained from 103 germinating conidia taken from colonies giving rise to variants or from mixed colonies on agar drops. All the isolates from a single conidium were identical with the original culture.

4. Cultural comparisons were made of 524 conidial isolates obtained from 205 individual conidiophores taken from mixtures of 2 distinct races or species growing on agar drops or from colonies derived from barley tissues infected with 2 or more distinct races or species of *Helminthosporium*. All the isolates from the same conidiophore, with two exceptions, were identical culturally.

5. Variants occur frequently in *Helminthosporium* spp. either in the form of sectors or "patches." Although *H. sativum* race 1 has been cultured for 17 years, it still gives rise, under certain conditions, to numerous variants of different types.

6. Potato-dextrose agar rendered stale by certain bacteria was found conducive to the development of variants.

7. The results indicate that genetic variation in *H. sativum* is caused primarily by nuclear change rather than by heterocaryosis.

UNIVERSITY FARM,
ST. PAUL, MINNESOTA

LITERATURE CITED

1. Buller, A. H. R. Researches on fungi. 5. 329 pp. Longmans, Green, and Company. 1933.
2. Christensen, J. J. Physiologic specialization and parasitism of *Helminthosporium sativum*. Minn. Agr. Exp. Sta. Tech. Bull. 37. 1926.
3. — & F. R. Davies. Does heterocaryosis account for the production of variants in *Helminthosporium*? (Abs.) Phytopath. 26: 89. 1936.
4. Dickinson, S. The nature of saltation in *Fusarium* and *Helminthosporium*. Minn. Agr. Exp. Sta. Tech. Bull. 88. 1932.
5. Eide, C. J. The pathogenicity and genetics of *Gibberella Saubinetii* (Mont.) Sacc. Minn. Agr. Exp. Sta. Tech. Bull. 106. 1935.
6. Graham, T. W. Nuclear phenomena in *Helminthosporium gramineum*. Phytopath. 25: 284-286. 1935.
7. Hansen, H. N. A phenomenon in Fungi Imperfecti. Sci. 82: 593. 1935.
8. — & R. E. Smith. The mechanism of variation in imperfect fungi: *Botrytis cinerea*. Phytopath. 22: 953-964. 1932.

9. Henry, A. W. Root-rots of wheat. Minn. Agr. Exp. Sta. Tech. Bull. 22. 1924.
10. Kuribayashi, K. The ascigerous stage of *Helminthosporium sativum*. Trans. Sapporo Nat. Hist. Soc. 10: 138-145. 1929. (Abs.) Rev. Appl. Myc. 8: 438-439. 1929.
11. Leonian, L. H. Attempts to induce "Mixochimaera" in *Fusarium moniliforme*. Phytopath. 20: 895-901. 1930.
12. Shands, H. L., & J. G. Dickson. Variation in hyphal-tip cultures from conidia of *Helminthosporium gramineum*. Phytopath. 24: 559-560. 1934.
13. Stakman, E. C., J. J. Christensen, C. J. Eide, & Bjorn Peturson. Mutation and hybridization in *Ustilago Zeae*. Minn. Agr. Exp. Sta. Tech. Bull. 65. 1929.
14. Ullstrup, A. J. Studies on the variability of pathogenicity and cultural characters of *Gibberella Saubinetii*. Jour. Agr. Res. 51: 145-162. 1935.

CYTOLOGICAL STUDIES IN THE TREMELLACEAE. IV.¹ PROTODONTIA AND TREMELLODENDRON

R. M. WHELDEN

(WITH 2 FIGURES)

In every group of organisms there occur members which differ so strikingly from the common nature of the group as to arouse one's interest. The Tremellaceous fungi are no exception to this statement, for in this family one finds the effuse *Protodontia* with its surface thickly studded with the short teeth which give it its name, and the earth-dwelling *Tremellodendron* with its erect much-branched fruit-bodies so like those of certain species of *Clavaria*.

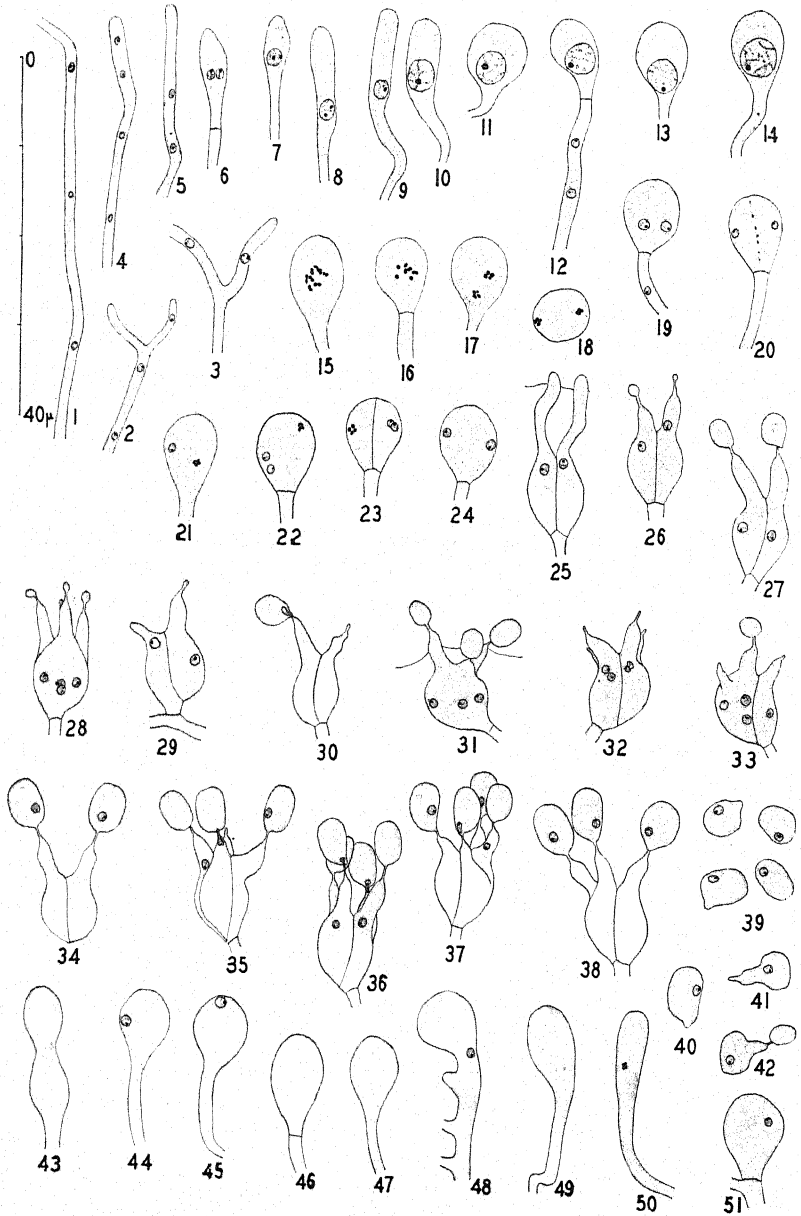
An examination of the literature on the cytology of fungi reveals very little dealing with either of the fungi considered in the present paper. *Tremellodendron* seems to be entirely untouched, while *Protodontia* fares little better; in fact, unless one considers Kühner's *Protohydnum lividum* Bres. (1) to be a *Protodontia*, one can report again that no work has been done. But as Martin (2) has pointed out, *Protohydnum lividum* Bres. may well be a *Protodontia*, so it seems well to consider briefly Kühner's results. He found the basidium initial to contain two nuclei whose early union formed the fusion nucleus. The latter rapidly enlarged in the swelling basidium, and developed a very definite chromatin content. The first division spindle was conspicuously transverse in the basidium; on it the chromosomes were confusedly clumped, and indeterminate in number. A second division followed. Four short, widely separated epibasidia developed and bore distally each a single spore which received a single nucleus. The spore readily germinated by a short slender tube through which the single nucleus migrated without dividing. Kühner's observations on this fungus were not extensive, and did not include any

¹ Contribution from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University, no. 146.

particular details as to the progressive changes which took place. Whether Kühner's fungus was the same as the *Protodontia* here studied, the writer is not prepared to state. Suffice it here that the writer's determination of his fungus as *Protodontia uda* v. Höhnelt has since been independently verified by Dr. D. P. Rogers, who has compared it with the type specimen and finds it to agree therewith exactly. In earlier papers (3) the writer has described in detail various changes in the life-history and cytology of the genera of Tremellaceae more commonly found in this region, pointing out particularly the details observed in the nuclei in various parts of the fruit-body. The present paper treats in similar fashion two more members of the family, which, though showing in their cytology details quite similar not only to the genera previously studied but also to each other, yet are so different in appearance and in several particulars as to justify separate treatment.

PROTODONTIA UDA v. HÖHNELT

The habit of this fungus has been sufficiently described above, so that one may pass directly to a consideration of its component parts. Of these the first to appear is the mycelium, composed of an inconspicuous web of slender hyphae, penetrating for short distances into the substratum, but more conspicuous in forming a thin layer of loosely aggregated intertangled hyphae extending over the substratum. The hyphae in this region extend parallel to the substratum, have a very thin inconspicuous layer of cytoplasm, and contain minute nuclei somewhat irregularly scattered in the very long segments (FIG. 1: 1). On approaching the surface of the fruit-body, the hyphae become slightly larger in diameter, acquire a denser cytoplasm and more evident but still very small nuclei which tend to become rather numerous in the hyphal tips (FIG. 1: 4, 5). Branching occurs frequently and rather irregularly, with the nuclei very irregularly distributed therein (FIG. 1: 2, 3); this branching is particularly abundant in the teeth. In the various parts of the mycelium, but especially near the hyphal tips, nuclear divisions occur abundantly. The small size of the nucleus makes it very difficult to observe exactly any details of the process. It is, however, fairly evident that four very minute chromosomes are formed in each nucleus during division. No

FIG. 1. *Protodontia uda*.

clamp connections were seen in any part of the mycelium. The presence of abundant moisture, by swelling the "jelly" surrounding the hyphae, separates them, making observation easier.

Basidium. Many hyphal tips, both in the surface of the projecting teeth and in the flat portion between these, are distinguished by their increasingly dense cytoplasm and by the presence therein of the two closely associated nuclei. These, the hypobasidium initials (FIG. 1: 6), slowly enlarge in diameter, sometimes becoming fusiform (FIG. 1: 7) in shape, but more often long cylindrical (FIG. 1: 8-10). With enlargement occurs fusion of the two small closely associated nuclei. After fusion of the two associated nuclei, the resulting nucleus enlarges, as does also the hypobasidium. It is worthy of notice that in this fungus the fusion nucleus becomes quite conspicuously swollen before any striking enlargement of the hypobasidium has taken place (FIG. 1: 10). Furthermore this enlarging fusion nucleus constantly remains quite remote from the apex of the hypobasidium. As the nucleus nears its maximum size, the basidium begins rapidly to enlarge to a shape approximately spherical, and often with a considerable stalk above the basal septum (FIG. 1: 11-14). At times the basal septum forms simultaneously with the fusion of the two nuclei, and at others its formation is delayed until the division of the enlarged fusion nucleus is nearly completed. The mature hypobasidium is a subspherical to short ellipsoidal body $7-8\mu$ in diameter, containing a fusion nucleus $3.7-4\mu$ in diameter and almost invariably situated at the very base of the enlarged portion. Throughout its existence, the fusion nucleus has contained a very evident but minute nucleolus which only disappears at the time when the chromosomes become distinct. More difficult to determine is the exact nature of the chromatin in the fusion nucleus: it is quite obvious that the chromatin forms into linear masses which become increasingly distinct as the nucleus enlarges. Whether these chromatin masses are separate entities of definite number from their inception it is impossible to determine. As nuclear enlargement ceases, contraction of chromatin masses suggests that they are separate units from their start. With complete contraction are formed eight small but very distinct chromosomes somewhat irregularly arranged but as a group located much nearer the center of the hypo-

basidium than was the fusion nucleus (FIG. 1: 15, 16). These eight chromosomes separate equally, moving usually to a position near the wall of the hypobasidium and equidistant from the apex, but occasionally located diagonally in the hypobasidium (FIG. 1: 17, 18). Surrounding the nuclei is a relatively clear region which elongates as they separate but which does not exhibit any special structural details. At the end of the separation of the chromosomes the two daughter nuclei become definitely organized, and are only slightly larger than the nuclei occurring in the mycelium. Normally a second division follows immediately after the first, commonly simultaneously for the two nuclei; not infrequently one nucleus divides independently, while many cases may be observed in which no second division occurs. Consequently the mature hypobasidium may contain four, three, or only two nuclei, variously located in a now increasingly vacuolate protoplasm. In this second division four chromosomes are present in each nucleus.

The time of formation of the longitudinal septa in the hypobasidium is very variable, most frequently occurring after all nuclear divisions have ended. Almost invariably the direction of the septum is such that it divides the hypobasidium quite regularly from base to apex. However, inconspicuous variations do occur, particularly in the hypobasidia located at the base of the teeth or in the region between teeth, where hypobasidia may be divided unequally (FIG. 1: 29, 32, 33). At times the longitudinal septa entirely fail to form; at least, one may frequently find hypobasidia as in figure 1: 31, at a very advanced stage of development, yet showing no indication of any longitudinal septation.

In this fungus, epibasidial development seems not to start until all nuclear divisions are completed. The number of epibasidia formed appears invariably to equal the number of nuclei eventually found in the hypobasidium. The epibasidia developing between the teeth or at their bases are short blunt objects sometimes nearly parallel to each other, but more frequently growing out at wide angles (FIG. 1: 28-33). Often they are so short that the sterigmata appear to grow directly from the hypobasidium (FIG. 1: 37). The dimensions attained are from 2-3.5 μ in length, with a diameter of 1.5-2 μ . In the teeth, epibasidia develop more regularly, sometimes reaching a length of 10-12 μ . They often protrude

quite noticeably beyond the relatively scant "jelly" before contracting rather abruptly into the short, very slender sterigmata which form from their tips.

At the tip of each sterigma, a spore is formed in a manner exactly like that described for other members of the family—that is, there forms at the tip of the sterigmata a small spherical object which rapidly increases in size until the diameter of the mature spore is attained, and then elongates slightly. The same irregularity in time of spore formation occurs here as has been noticed elsewhere (*i.e.* Whelden, 4), frequent instances being found where one of two to four epibasidia bears a mature spore before any other has started to form (FIG. 1: 30, 33).

Nuclear migration usually begins only when the spore has attained its mature size. Each nucleus migrates independently of its fellows, and moves with little change in shape except during the actual passage through the slender sterigma. Following migration of the nucleus there is rapid and almost complete withdrawal of all cytoplasm in the basidium, which however remains in an uncollapsed condition for some time, often until it is deeply immersed in a continually growing fruit-body.

The mature spores are conspicuously vacuolate uninucleate objects whose dimensions are $4-7 \times 3.5-4.5 \mu$. Soon after falling from the sterigma each spore germinates by a short, coarse germ-tube at the apex of which is formed a slender tip bearing a secondary spore similar to the primary one. Into this secondary spore the nucleus migrates without dividing. Further development was not followed.

Sterile bodies. There remain for consideration the various structures which may best be designated sterile bodies. These are more frequently encountered in the flattened surface of the fruit-body than in the teeth, and are all quite obviously of the same nature, namely, all are explainable as basidia which for some reason failed to develop as such. The structure most frequently found is very like the hypobasidium just before formation of the septa and development of the epibasidia; that is, they are subspherical objects located in the hymenium and having exactly the dimensions of the basidia (FIG. 1: 44-47, 49, 51). One striking contrast with a hypobasidium is observed, however, in that

these sterile structures contain very little cytoplasm which is usually present as a thin inconspicuous layer against the wall. Equally characteristic, if less conspicuous, is the nuclear nature of these structures—there is always a single small nucleus which may occupy any position within the cytoplasm. The explanation which suggests itself is that these are hyphal tips which received but one nucleus, and that they enlarge as do normal hypobasidia but do not develop the same abundance of cytoplasm. They finally become devoid of any cytoplasm, and remain as empty but distended bodies for a considerable time. At times one finds in these or in tips less swollen and provided with more evident cytoplasm a single small nucleus in a definite state of division, sometimes even showing four small closely massed chromosomes (FIG. 1: 50). These are not normal hyphal tips, however, since all are distinctly swollen and show definite thinness of cytoplasm which seems characteristic of these sterile objects. Quite infrequently one or more branches develop from the stalk-like portion of these sterile tips—these branches seem never to grow to any great extent, nor were they seen to contain any nuclei (FIG. 1: 48). Even less frequently one encounters tips in which more than one swelling occurs (FIG. 1: 43); no stages could be observed in the development of the latter. All these structures are found scattered among normal basidia, and seem in no way to be correlated with abnormal conditions, such as drought, but rather to be a natural development of the fungus.

TREMELLODENDRON CANDIDUM

The mycelium of the fruit-body of this fungus shows several different regions having rather distinct characteristics. Arising from the sandy soil in which the fungus was growing and forming the central portion of the much-branched fruit-body is a relatively dense zone of rather coarse hyphae containing a very scant peripherally located cytoplasm. Individual hyphae here are reasonably straight, branch but little, and have many septations, which form segments commonly containing one or two minute nuclei rather remote from one another (FIG. 2: 40); not infrequently segments are found entirely lacking nuclei. In the large number of slides made there were many which showed the cells in this central por-

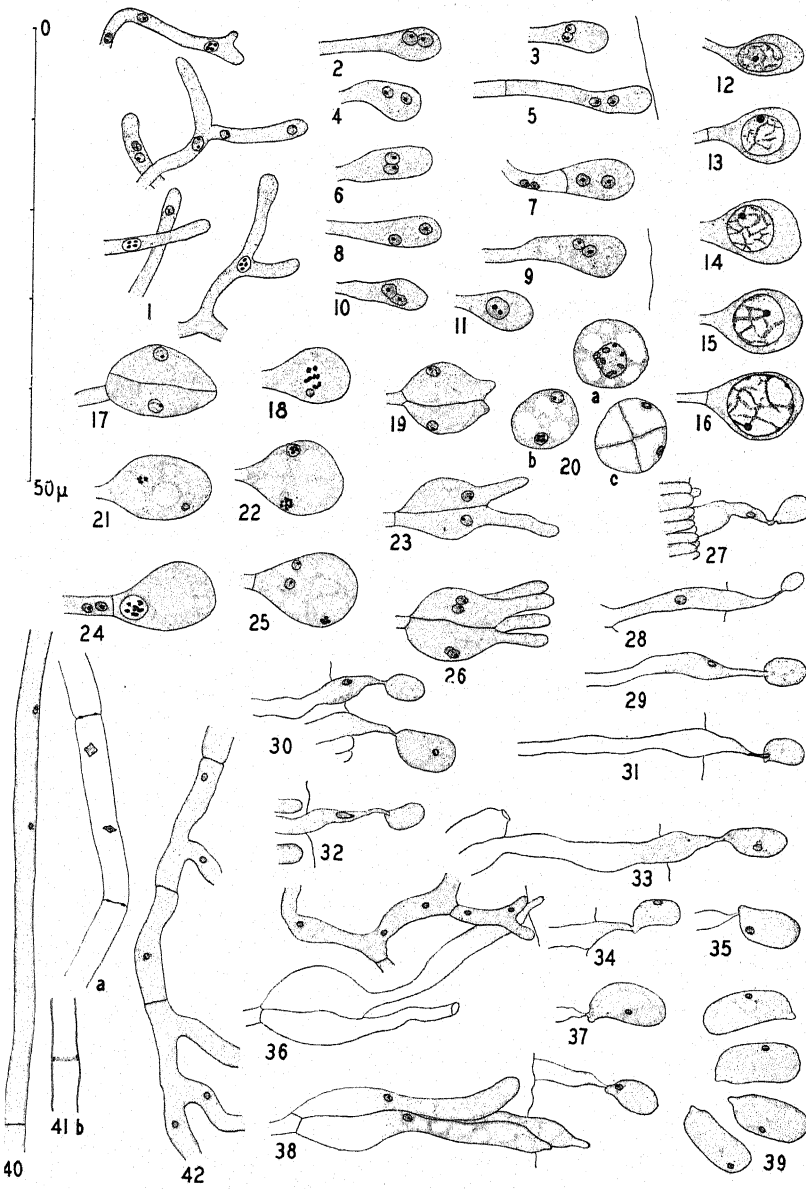


FIG. 2. *Tremellodendron candidum*.

tion containing one or two small dark-staining angular objects apparently of crystalline nature (FIG. 2: 41a). The similarity of their distribution to that of the nuclei suggests a possible connection between them. Casual examination would lead to their identification as nuclei; closer attention shows clearly their characteristic shape of thin square bodies with concave sides. The cross walls also are troublesome; many show a curious ring-like dark-staining portion appearing in section as two thick bars near the peripheral part of the wall (FIG. 2: 41a, b). The presence of these ring-like septa is more general than is that of the crystal-like objects.

External to this central zone of hyphae is a layer sharply set off from the first by its structure of loosely arranged, intricately tangled and irregularly much branched hyphae again composed of many segments of very diverse nuclear content (FIG. 2: 42). Often only one nucleus is present in a segment, more commonly two, and in rare cases three or more. In this layer also the hyphae are distinguished by the possession of a noticeably denser cytoplasm, while crystals and modified cross-walls are lacking.

Nearer the surface of the fruit-body this layer gradually blends into a third region less sharply set off from the second but still recognizably distinct. The hyphae comprising this surface layer are of smaller diameter, have conspicuously denser cytoplasmic content, possess noticeably larger nuclei not located peripherally, and in a growing condition are more obviously surrounded by "jelly" (FIG. 2: 1). The development of cross walls seems somewhat delayed in this superficial layer, so that there is a tendency for tips to be multinucleate. While rather small, many nuclei clearly showed the presence of four distinct minute chromosomes. The rounded tips of these hyphae do not form a dense surface layer but remain instead rather loosely arranged, a condition which continues throughout the period of basidial formation.

Basidia. Rather widely scattered beneath or at the surface of the maturing fruit-body, certain hyphal tips gradually become distinct through the presence of two closely associated nuclei, and also because of a very obvious enlargement. These enlarged tips seem invariably to be oriented horizontally, while within them the two nuclei occupy almost any relative position (FIG. 2: 2-10, inclusive). Frequently a basal septum cuts off the tip before nuclear

fusion occurs, the location of the septum being extremely variable; but usually not at the base of the enlarged portion.

Following fusion of the nuclei that of the nucleoli occurs, while both the basidium and the nucleus therein (FIG. 2: 11-15) continue to enlarge, until the latter has reached a diameter of 10μ (rarely 12μ). As in all cases in this family, there is the early appearance of the chromatin aggregates which become increasingly distinct as the nucleus enlarges. In the present instance these chromatin masses are very definitely located just beneath the nuclear surface. In thin sections, only zones of the fusion nucleus occur, so that the basidium often presents the appearance of two concentric rings including a minute zone of cytoplasm, while within the inner ring are small bits of deeply staining substance located in a very thin film of more faintly staining material. At times it is possible to focus down into a "bowl"-like section of the nucleus and identify these darker staining masses as sections of the chromatin masses. By far the greater part of the nucleus is completely unstained and seemingly unstainable, so far as the many different stains tried during the present study indicate. The impression one gets is that the nucleus is largely made up of a liquid which by increasing in volume distends the nuclear membrane and forces all nuclear substance outward, until practically the entire hypobasidium is occupied by the fusion nucleus (FIG. 2: 16). Throughout this development, the very small nucleolus remains a conspicuous object near the nuclear surface. The average final dimensions of the hypobasidium are $12 \times 8\mu$, while the diameter of the included nucleus is 10μ .

Soon after maximum size is reached there occurs a rapid contraction of chromatin substance to form darker staining and distinct bodies still included by the nuclear membrane; the nucleolar substance begins to disappear; and the fusion nucleus shrinks rapidly from its maximum size (FIG. 2: 20a). As this contraction continues the nuclear membrane disappears, leaving eight small but perfectly distinct chromosomes free in the central part of the hypobasidium, which now contains a thin, vacuolate cytoplasm (FIG. 2: 18). Very rarely are the chromosomes located elsewhere than in the center of the hypobasidium; if elsewhere one generally finds them near the base, as in figure 2: 24 which shows them just

before the nuclear membrane disappears. Frequently a fairly evident pairing of the chromosomes may be observed.

Separation of chromosomes follows, the two groups migrating to a position near the wall of the hypobasidium and commonly in a transverse plane therein. Rather infrequently do they migrate in a longitudinal or diagonal direction, as shown in figure 2: 21. Having reached a position near the wall, the chromosome substance reorganizes to form the two daughter nuclei (FIG. 2: 17, 20*b*).

Ordinarily a second nuclear division follows immediately, the two nuclei usually dividing simultaneously, with four small chromosomes quite evident in each (FIG. 2: 22). These four chromosomes split equally so that eight pairs are frequently seen massed together in a nucleus, as in the lower nucleus of figure 2: 22. Quite commonly the two nuclei divide independently, as shown in figure 2: 21, 25, and 20*b*, while in other hypobasidia no second divisions occur. As a result of these variations, one may find hypobasidia which, at the end of the nuclear divisions, contain two, three, or usually four nuclei.

Septum formation seems not to be correlated with these nuclear events. As noted above, the time of formation of the basal septum, as well as its location, is extremely variable. Such is also the case in the longitudinal septa. As a rule the formation does not take place until nuclear divisions are completed; equally regular is their longitudinal orientation in the hypobasidium. When both have formed, the hypobasidium is divided into four almost equal parts. By this time the hypobasidium has become extremely vacuolate, with the minute nuclei located very close to the outer wall, often appearing somewhat flattened, as in figure 2: 20*c*.

Epibasidial formation begins in this fungus at the end of nuclear divisions and after the formation of the septa is completed. Nothing out of the ordinary is observable in their appearance as small apical protrusions (FIG. 2: 19) which gradually elongate until they reach the surface of the "jelly" of the fruit-body, at which time they may have a length of $24\ \mu$, with a somewhat variable diameter of $1\text{--}3\ \mu$ (FIG. 2: 23, 26). An epibasidium may protrude slightly beyond the "jelly" before contracting rather gradually to form the sterigma, a slender object which may attain a length of $3.5\ \mu$ (FIG. 2: 27-33).

Spore formation offers little of interest, the process being almost identical with that found in all members of this group so far studied. The mature spores are borne at right angles to the surface of the fruit-body, and when fully mature are vacuolate bodies $8-10 \times 3.5-4 \mu$ (FIG. 2: 39).

Nuclear migration begins while the epibasidia are still forming. The nuclei become somewhat elongated at the beginning of their migration, and increasingly so as they near the apex of the epibasidia (FIG. 2: 30, 32). The location of the nucleolus may be apical or basal in the migrating nucleus. Necessarily in passing through the slender sterigma the nucleus becomes extremely attenuated (FIG. 2: 31). Once through, it immediately regains its original shape in which condition it moves to its final position in the distal half of the spore (FIG. 2: 34, 35, 37, 38). Its further history was not observed. Even before the beginning of nuclear movement, and becoming increasingly noticeable as migration continues, is the withdrawal of the cytoplasm from the basal portion of the hypobasidium (FIG. 2: 38). This withdrawal becomes very conspicuous when the nucleus is in the outer part of the epibasidium, at which time the hypobasidium has become almost devoid of cytoplasm, remaining as an uncollapsed structure surrounded by growing, branching hyphal tips (FIG. 2: 29, 33, 36). As the nucleus enters the spore, the cytoplasm in the epibasidium disappears leaving that object also lacking content, except in rare cases when a trace of cytoplasm may persist for a time in the apical portion (FIG. 2: 36).

It is worthy of notice that in *Tremellodendron* the basidia do not form a dense continuous hymenium at the surface, but rather that they occur as single bodies rather remotely scattered in the superficial layer, and constantly developing independently over a considerable period of time. This fungus seems less dependent than other Tremellaceae on the presence of abundant water for continuous spore formation.

DISCUSSION

In *Protodontia* the objects which seem worthy of specific note are the epibasidia and the sterile structures. In this genus the

dimensions of the epibasidia are obviously correlated with the amount of "jelly" present, and also with their location in the fruit-body. Epibasidia found in the teeth are of considerable length, while in the flat portion of the fruit-body they are poorly developed; in fact, many hypobasidia have almost no epibasidial structure, the sterigmata seeming to grow directly from the apex of the hypobasidium. In this flat region there is very little "jelly" above the hymenium, and so little need for any structure to penetrate such a substance.

The sterile structures found in *Protodontia* are readily interpreted as abortive basidia, being distinguished from true basidia by having only one small nucleus and an extremely thin cytoplasm. From their appearance one may decide that the fusion of two nuclei is not essential to cause enlargement but is necessary for further development of these bodies.

These observations on *Protodontia* substantially agree with those made by Kühner on *Protohydnum lividum* Bres. (1).

In *Tremellodendron* four different facts are worthy of notice. These are the hyphal structure of the fruit-body, the nature of the hymenium, the increase in size of the fusion nucleus, and the entire absence of sterile structures in the hymenium.

The first of these is the most noticeable, sharply distinguishing this fungus from all the other Tremellaceae so far studied by the writer. In the others, the hyphal structure of the entire fruit-body is remarkably uniform, while in *Tremellodendron* the fruit-body is composed of three distinct layers of hyphae. First there is a large central portion composed of closely aggregated hyphae extending lengthwise in the fruit-body, and almost devoid of protoplasmic content. In this region the septa are seemingly in process of digestion and disappearance, often being represented only by thickened peripheral rings. Surrounding this central region is a sharply distinct layer of intricately entangled, much-branched hyphae having a denser cytoplasm and which extend radially rather than longitudinally. Near the surface this layer gradually blends into a less distinct outer layer in which the basidia develop. This body structure of *Tremellodendron* resembles that of certain species of *Clavaria* far more than that of any other member of the Tremellaceae.

The nature of the hymenium in this genus is also very distinct. In all the other Tremellaceous fungi it has formed a dense rather uniform layer over a considerable portion of the exposed surface of the fruit-body. In *Tremellodendron* the hymenium is not continuous and lacks sterile bodies. In its formation individual hyphal tips, remotely and irregularly scattered, develop into basidia. One finds separate basidia developing to maturity and disappearing in succession over a considerable period of time, indicating that this fungus is less dependent on abundant moisture for spore formation than are any of the other members of the family.

In the hypobasidium, the tremendous increase in volume of the fusion nucleus over the two minute primary nuclei is most remarkable. This large fusion nucleus is easily studied and shows quite obviously the peripheral distribution of chromatin as nuclear enlargement progresses. This seems explicable as a consequence of the increasing amount of water which expands the nucleus to the greatest possible extent.

This study shows that the general cytological history of all members of the Tremellaceae is very similar. In spite of this general agreement, however, certain noteworthy points of difference stand out.

SUMMARY

Protodontia and *Tremellodendron* have the same cytological history as the other genera of the Tremellaceae studied by the writer. The following differences are noted, however. In *Protodontia* the epibasidia are definitely affected by the amount of "jelly" surrounding the hypobasidium and vary from very inconspicuous objects found in the flat surface of the fruit-body to long well-developed bodies found in the teeth. In this genus basidia-like sterile bodies occur, each containing only one nucleus and a very scant cytoplasm. In *Tremellodendron*, the fruit-body is composed of three layers: a central mass of densely packed hyphae growing longitudinally in the fruit-body; surrounding this, a layer of radially growing much-branched hyphae; and at the surface a layer of slender tangled hyphae in which are formed the basidia. The basidia do not occur as a continuous layer, but individually. The large fusion nucleus of a mature basidium has the chromatin

peripherally located. No abortive structures were observed in *Tremellodendron*.

HARVARD UNIVERSITY

LITERATURE CITED

1. Kühner, R. Contribution à l'étude des Hyménomycètes et spécialement des Agaricacés. *Le Botaniste* 17: 1-224. 4 pl. 37 figs. 1926.
2. Martin, G. W. The genus *Protodontia*. *Mycologia* 24: 508-511. 2 figs. 1932.
3. Whelden, R. M. Cytological studies in the Tremellaceae: *Tremella*. *Mycologia* 26: 415-435. 3 pl., 11 figs. 1934. *Exidia*. *Mycologia* 27: 41-57. 4 pl. 1935. *Sebacina*. *Mycologia* 27: 503-520. 3 figs. 1935.
4. Whelden, R. M. Observations on the cytology of a new species of *Sebacina*, *S. globospora*. *Rhodora* 37: 121-128. 1 pl. 1 text fig. 1935.

DESCRIPTION OF FIGURES

Fig. 1. *Protodontia uda* 1, multinucleate bit of mycelium from flat part of fruit-body; 2, 3, branched hyphal tips in surface of teeth; 4, 5, unbranched hyphal tips; 6, binucleate basidium initial; 7, 8, early stage of fusion nucleus, nucleoli distinct; 9, 10, enlarging fusion nuclei in as yet slightly swollen hypobasidia; 11-14, nearly mature hypobasidia, showing basal location of nucleus; 15, 16, chromosomes in center of hypobasidia; 17, separating chromosomes; 18, transverse section of hypobasidium, showing chromosomes at end of separation; 19, 24, binucleate hypobasidium; 20, formation of first longitudinal septum in hypobasidium; 21, 22, non-simultaneous second divisions before formation of longitudinal septa; 23, non-simultaneous second division after septum formation; 25, mature hypobasidium becoming vacuolate as nuclei migrate into epibasidia; 26, early spore formation in another binucleate basidium; 27, spores well advanced, cytoplasm leaving hypobasidium; 28, four-nucleate hypobasidium with well-developed epibasidia; 29, 30, hypobasidium showing unequal development of epibasidia; 31, 3-nucleate hypobasidium nearly mature but lacking septa; 32, 4-nucleate hypobasidia at beginning of nuclear migration; 33, irregular 4-nucleate basidium; 34, mature two-spored basidium; 35-37, 4-spored basidium showing non-uniform nuclear migration; 38, mature 3-spored basidium; 39, 40, mature spores; 41, 42, germination stages of spore; 43, sterile body showing two swellings; 44-49, various forms of uninucleate sterile bodies; 50, another with dividing nucleus; 51, basidia-like body having very short stalk.

Fig. 2. *Tremellodendron candidum* 1, hyphal tips in superficial layer of fruit-body; 2-10, binucleate basidial initials; 11, basidium with fusion nucleus, but unfused nucleoli; 12-15, hypobasidia with enlarging fusion nucleus; 16, mature fusion nucleus in hypobasidium; 17, binucleate hypobasidium with first longitudinal septum; 18, chromosomes free in hypo-

basidium; 19, binucleate hypobasidium with epibasidia forming; 20, cross sections of hypobasidium showing (*a*) formation of chromosomes, (*b*) binucleate condition, and (*c*) final 4-celled condition, two nuclei in plane of section; 21, non-simultaneous second nuclear division; 22, simultaneous second nuclear division; 23, mature hypobasidium with two well-developed epibasidia; 24, abnormal location of chromosomes at base of hypobasidium; 25, hypobasidium showing later stage of non-simultaneous division of nuclei; 26, mature hypobasidium with four well-developed epibasidia; 27-34, epibasidia showing stages in spore development, and in the nucleus during migration; 35, 37, nearly mature spore still attached to epibasidium; 36, empty hypobasidium with adjacent hyphal tip; 38, mature hypobasidium with three well-developed epibasidia; 39, mature spores; 40, hypha from central part of young fruit-body; 41, hyphae from central part of older fruit-body showing (*a*) included crystals, and (*b*) ring-like septum often present; 42, segmented hypha from second layer of fruit-body.

OBSERVATIONS ON SEXUAL RELATIONS IN HYPOMYCES IPOMOEAE

A. W. DIMOCK

(WITH 2 FIGURES)

The occurrence of strains of different sexual reactions in the Ascomycetes was first discovered by Dodge (12) in the genus *Ascobolus*. Since this discovery, the following Ascomycete genera have been shown to possess such sexual strains: *Ophiobolus* (Kirby, 24), *Gibberella* (Wineland, 28, 29), *Penicillium* (Derx, 10), *Neurospora* (Shear and Dodge, 26), *Ceratostomella* (Dade, 8; Gregor, 20; Buisman, 4), *Pleurage* (Dowding, 16; Ames, 1; Zickler, 31 [*Bombardia*]), *Sclerotinia* (Drayton, 17), *Hypomyces* (Zycla, 32), and *Erysiphe* (Yarwood, 30). Kirby's report (24) of heterothallism in the genus *Ophiobolus* has since been questioned by Davis (9). Likewise, Derx' report (10) of heterothallism in the genus *Penicillium* has been disputed by Blochwitz (3). Although Edgerton (19) early reported the occurrence of plus and minus strains in the genus *Glomerella*, both strains, though interfertile, were hermaphroditic and self-fertile as well. Hüttig (23) has recently published the results of studies of heredity in this genus. Only one of the strains used in his investigations was unisexual in reaction, however, the other being hermaphroditic and self-fertile.

An investigation of the sexual relations in *Hypomyces Ipomoeae* (Hals.) Wr., the imperfect stage of which is *Fusarium javanicum* Koord., was suggested to the writer by Professor H. N. Hansen. This fungus was known to produce perithecia in abundance and in a relatively short time on sterilized elderberry stems, but intensive studies of conditions required for perithecium formation had not been undertaken. An elderberry stem on which numerous perithecia of *H. Ipomoeae* had developed was kindly provided by Dr. W. C. Snyder of the California Agricultural Experiment Station staff. The fungus had originally been isolated by Dr. Snyder

from sweet-potato roots, and the sterilized elderberry stem planted with mycelium from a spore dilution plate. The dry stem was placed by the writer in a sterile test tube containing a few cubic centimeters of sterile water, and in a short time new perithecia developed in abundance.

DISCOVERY OF SEXUAL-REACTION GROUPS

A newly matured perithecium was removed from the stem with the aid of a sterile needle, washed in several changes of sterile water to remove adhering spores and finally placed in a drop of water on a sterile slide. The perithecium was then crushed with the point of a sterile needle, the operation being observed under the low power objective of the microscope. Mature ascospores were disgorged in large numbers when the rind of the perithecium was broken, and after adding a few drops of sterile water to reduce the spore concentration, the suspension was streaked on Petri plates of Czapek's agar by means of a sterile loop. The following day each mature spore had produced a germ tube 3 or 4 times the length of the spore. Isolated sporelings were then located by observations through the bottom of the Petri plates with the low power objective of the microscope and the locus of each marked with a dot of India ink. The plates were then righted and small bits of agar bearing the sporelings were transferred to slopes of malt extract agar in 1" \times 8" culture tubes, the removal from the plates being observed with the aid of a dissecting microscope. In most cases the sporelings were examined with the 45 \times objective of a compound microscope prior to transfer from the plates in order to check their purity. The presence of conidial contaminants or more than a single ascospore would of course vitiate the results.

The above technique was used in all the earlier studies and gave quite satisfactory results. The method, however, is very slow and laborious, and for this reason a modification of the method of Hansen and Smith (21) was employed in later work. Spores were streaked on agar and germinated as described above, but isolated sporelings were located directly with a dissecting microscope employing direct lighting. The spores were immediately removed with a sharp, sterile needle and either transferred directly to agar

slopes or first placed on a sterile spot on the agar plate, examined with the high-power objective of the microscope, and then transferred to the culture tubes. Ascosporelings were in every case examined with the compound microscope prior to transferring to culture tubes. An enormous saving of time was effected by this method with no sacrifice of accuracy.

Ninety-five single-ascospore cultures on malt-extract agar slopes were obtained from the initial perithecium, and in addition 5 sterilized elderberry stems were planted with a single ascosporeling, and 4 were planted with 2 single ascosporelings. Perithecia developed in abundance on three of the four stems on which 2 ascosporelings were planted, whereas none developed on the fourth. No perithecia developed on any of the five stems planted with a single ascosporeling. This preliminary test strongly indicated the presence of self-sterile strains of opposite sexual reactions.

In the meantime the 95 single-ascospore cultures on malt slopes had remained essentially alike, and none had developed perithecia. The term "essentially alike" is used here advisedly, for no two cultures are ever identical, slight variations occurring due to small differences in the amount of medium, differences in the cleanliness of the glass tubes, differences in the amount of agar transferred with the spore, etc. Such variations are slight and their range quickly learned, so that they lead to no confusion. Eighteen of these cultures were taken at random and mated in all possible combinations on sterilized elderberry stems. The cultures fell into two intra-sterile, inter-fertile groups, 13 cultures comprising one group, 5 the other. The reactions were in every case quite clear-cut. *The occurrence of self-sterile strains of opposite sexual reaction in Hypomyces Ipomoeae is thus definitely proved.*

A phenomenon was noted in nearly all the above sterile cultures which, until understood, caused some anxiety. This was the appearance of small, reddish, spherical bodies which closely resembled young perithecia. Microscopic examination of these bodies, however, showed them to be quite sterile. The control cultures of the single-ascospore strains were carefully re-examined and similar sterile perithecium-like bodies were found in nearly all cultures, whether of one sexual reaction or the other. This ob-

servation has been borne out in all subsequent work with the normal strains.

Similar sterile bodies were noted by Dodge (13) in *Neurospora sitophila* strains of both sexual reactions. He termed them "sclerotia" or "bulbils" and considered them to function as true sclerotia. Colson (5), by cytological investigation, has shown that these "sclerotia" are in reality perithecial fundaments, being composed of sterile hyphae in which the "archicarps" are encased. Sterile-bodies are also reported by Ames (1, 2) and Zickler (31 [*Bombardia*]) in strains of both sexual reactions in the genus *Pleurance*. Ames proved unquestionably that these bodies encase the female sex organs. Gregor (20) has noted such sterile bodies in strains of both sexual reactions in *Ceratostomella plurianulatum*, and regards them as female sex organs. Hüttig (23) reports the occurrence of "sklerotia" in his "male" strain of *Glomerella Lycopersici*. He considers these sterile bodies as male sex organs—"Die 'Sklerotia' enthalten nur Hüllhyphen und Antheridien." In view of the researches of Colson (5) and Ames (1, 2) noted above, and of Drayton (17, 18) on *Sclerotinia Gladioli*, in which the sterile bodies in *Neurospora*, *Pleurance* and *Sclerotinia* are proved to be female in nature, Hüttig's interpretation is open to question.

Cytologic investigations of the sterile bodies in *Hypomyces Ipomoeae* were not undertaken, but by analogy to the above cases they are assumed to be perithecial fundaments and to be female in nature. This hypothesis is supported by the observation that in all fertile pairings the fundaments proceed to develop into fertile perithecia. It is thus proposed that the strains of opposite sexual reactions in *Hypomyces Ipomoeae* are hermaphroditic and self-sterile, but inter-fertile. The existence of such strains in *Pleurance anserina*, *Sclerotinia Gladioli*, *Neurospora tetrasperma* and *N. sitophila* has been proved by Ames (1, 2), Drayton (17, 18) and Dodge (14). These species possess not only female bodies but also male sex organs which produce spermatia ("microconidia" in *Neurospora*, Dodge, 14), thus permitting definite proof of hermaphroditism, self-sterility and inter-fertility. Examination has thus far disclosed no male sex organs in either strain of *Hypomyces Ipomoeae*, but evidence will be presented

later which suggests that the conidia may function in the capacity of spermatia, as has been proposed by Dodge (14) for the monilioid conidia of *Neurospora*.

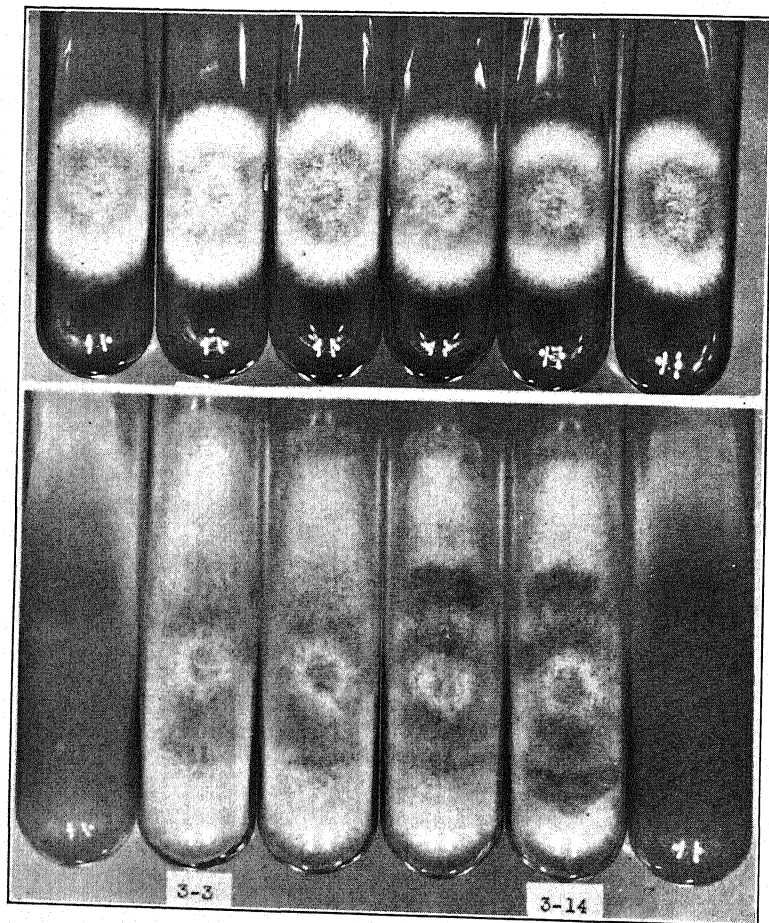


FIG. 1. Single-conidium cultures of the normal strains of *Hypomyces Ipomoeae* on potato-dextrose agar. In each photo the 3 cultures on the left bear the sexual-reaction factor *A*, the 3 on the right the factor *a*. Upper, cultures 4 days old; lower, cultures 9 days old.

Two self-sterile, inter-fertile strains, 3-3 and 3-14 (FIG. 1), were selected from the above 18 single-ascospore mycelia to serve as tester strains in all subsequent studies. Following the precedent

of Zickler (31) and Dodge (15), the two strains have been assumed to bear sexual-reaction factors designated as *A* and *a*, respectively. These strains were mated on numerous media and it was soon apparent that perithecia, which developed in all matings, were produced most rapidly on ordinary potato-dextrose agar. This medium has hence been used in nearly all matings. Single-ascospore mycelia from seven perithecia developing in various $3-3 \times 3-14$ crosses have been tested for sexual reaction. The results are indicated in Table 1.

TABLE 1
DISTRIBUTION OF SEXUAL-REACTION FACTORS IN SINGLE-ASCOSPORE CULTURES
OF HYPOMYCES IPOMOEAE

| Perithecium | Sexual-reaction factor | | Ratio <i>A/a</i> |
|------------------------|------------------------|----------|------------------|
| | <i>A</i> | <i>a</i> | |
| X | 10 | 6 | 1.67/1 |
| E1 | 12 | 8 | 1.50/1 |
| E2 | 12 | 16 | 0.75/1 |
| E3 | 11 | 26 | 0.42/1 |
| E4 | 12 | 8 | 1.5/1 |
| E6 | 28 | 23 | 1.22/1 |
| E7 | 10 | 8 | 1.25/1 |
| Total | 95 | 95 | 1/1 |
| Initial perithecium | 13 | 5 | 2.60/1 |
| Total | 108 | 100 | 1.08/1 |

The data show that of the 190 single-ascospore mycelia, 95 possessed sexual-reaction factor *A*, 95 the factor *a*—an exact 1:1 ratio. If data on the initial perithecium are included the values become 108 and 100, respectively, and the ratio 1.08:1. A 1:1 ratio would be expected on the assumption that sexual reaction is conditioned by a single gene pair. It is therefore concluded that sexual reaction in *Hypomyces Ipomoeae* is conditioned by a single pair of factors which segregate at meiosis according to Mendelian expectancy.

The tests of sexual reaction were at first made by back-crossing each single-ascospore culture with both tester strains. This method obviously involved considerable transferring and was so time-consuming that a more simple, but equally reliable, test

method was sought. The following procedure was found in trials to be quite satisfactory, and was used to determine the sexual reaction of all normal mycelia in subsequent tests. One cubic centimeter of a concentrated suspension of microconidia of one tester strain or the other in sterile distilled water was added to each single-ascospore culture to be tested. Within 5 days perithecia could be seen with the naked eye to be developing on all parts of the culture which had been wet with the spore suspension (FIG.

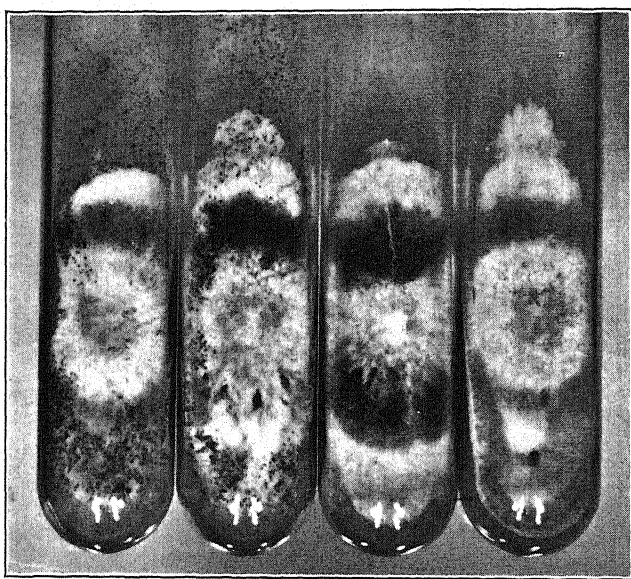


FIG. 2. Old cultures of normal strains which have been "spermatized" with a suspension of microconidia of the tester-strain (3-14) bearing sexual-reaction factor *a*. The two cultures on the left must bear sexual-reaction factor *A*, the two on the right the factor *a*.

2). The age of the single-ascospore cultures so tested varied from 10 days to more than three months, and in all cases the same definite results were obtained. The reaction is so pronounced that the development of perithecia may be taken as proof that the sexual reaction of the single-ascospore strain is opposite that of the tester strain. Failure to develop perithecia, on the other hand, may be taken as definite evidence that the sexual reaction of the ascospore strain is the same as that of the tester.

It has been observed that in all cases in which the above method has been used, perithecia developed only on those portions of the colony which had actually been wetted by the microconidial suspension. When single drops of spore suspension were added, perithecia developed only within the limits of the drop. Furthermore, since the perithecia become quite evident in 5 days, it is obvious that their development is initiated very soon after the addition of the spore suspension. In single-spore cultures, perithecial fundaments develop when the cultures are 8 or 9 days old, and in normal matings fertile perithecia become evident when the cultures are 10 or 15 days old. All single-ascospore cultures to which spore suspension has been added have been old enough to have developed perithecial fundaments in abundance. This, coupled with the fact that perithecial development immediately ensues only on those portions of the cultures actually wetted by the spore suspension, leads to the conclusion that conidia (or perhaps any vegetative cells) may function in spermatizing the perithecial fundaments, which have been assumed to bear the female sex organs. The ability of both microconidia and macroconidia of *Neurospora tetrasperma* and *N. sitophila* to function in spermatization has been previously demonstrated by Dodge (14) with similar experimental methods.

Throughout the course of this investigation watch has been kept for secondary sexual characters in the normal strains, *i.e.*, morphologic or physiologic expressions definitely linked with the strains of one sexual reaction or the other. Five consecutive culture-series consisting of 25 single conidia each have been made of both tester strains, malt-extract agar being used as the substrate. Scores of mass transfer and single conidium cultures of the two strains on various other substrates have also been observed. It was at times believed that definite differences of one sort or another could be discerned, but none of these proved constant. An example of such a difference is illustrated by the cultures pictured in figure 1. All three of the 9-day-old cultures of 3-14 (*a*) apparently have a pigmentation of the basal mycelium not possessed by any of the three cultures of 3-3 (*A*). All such dissimilarities have proved evanescent or so poorly marked as to

be unreliable. The "normal" strains of opposite sexual reactions may be regarded as morphologically indistinguishable.

Mention must be made here of certain variant mycelia. A single ascospore, E3/1, developed a very unusual type of mycelium which bore no resemblance to the normal, being extremely slow-growing, developing very few conidia, and possessing marked reddish-purple pigmentation. Again, a number of single ascospores have developed a distinct "purplish" type of growth which resembles the normal in growth-rate and fluffiness of mycelium, but which develops purple pigment and produces conidia much less abundantly than the normal. Fourteen of the 208 single-ascospore cultures have been of this type. Since we are concerned here only with sexual phenomena, suffice it to say that all the variants were fertile, and those of the "purple" type showed an almost exact 1:1 distribution of the sexual-reaction factors. A detailed discussion of these and other ascospore variants will be included in a later paper. All single-ascospore cultures save the 15 noted above have fallen well within the normal limits.

DISCUSSION ON SEXUAL PHENOMENA IN *HYPOMYCES IPOMOEAE*

The experiments reviewed in the preceding pages have proved beyond question the existence of monoploid, self-sterile, inter-fertile strains in *Hypomyces Ipomoeae*. Observations on the presence of perithecial fundaments in monosporous mycelia of either reaction, and observations on the apparent spermatizing action of conidia are believed good evidence that both strains are hermaphroditic and are completely inter-fertile.

Hermaphroditic mycelia in this species are seen to arise from single ascospores and from single unicellular microconidia. Although cytologic studies of ascospore formation in this species have not been undertaken, we may assume that, as is conceded to be the case in most Ascomycetes possessing 8-spored asci, each ascospore initially contains a single haploid nucleus. Cytologic studies of Dickinson (11) on certain species of *Fusarium*, and preliminary studies made by the writer on *Hypomyces Ipomoeae*, indicate that most unicellular microconidia of *Fusarium* species contain but one nucleus at the time of abstriction. These observa-

tions lead to the conclusion that in this and other similar forms (*Pleurage*, *Sclerotina*, 8-spored *Neurospora* spp.) each monoploid nucleus possesses the potentialities of both sexes. This theory has been supported by Correns (6, 7), Wettstein (27), Hartmann (22), Ames (2), and others.

Sex chromosomes or sex genes as such are not, then, segregated in the maturation divisions. It must be assumed, rather, that an allelomorphic pair, *Aa*, determining fertility and sterility is concerned. Matings of two strains bearing the factor *A*, or of two strains bearing the factor *a*, would be sterile, while matings of two strains, one bearing *A* and the other *a* would be fertile. The theory of sterility factors or compatibility factors has likewise been advanced to explain the condition in *Neurospora* (Lindegren, 25) and in *Pleurage* (Ames, 2; Zickler, 31).

The mode of operation of such reaction-factors is suggested by the work of Ames (2) on *Pleurage anserina*. He found that when a spermatium from a compatible strain was applied to a receptive hypha of an ascogonium, it soon lost its contents, and the ascogonium developed a fertile perithecium. Incompatible spermatia, or spermatia from the same mycelium, when similarly applied, did not lose their contents, nor did the ascogonia develop perithecia. In the present case it may be that hyphal fusion or spermatization by conidia is prevented between strains bearing like sexual-reaction factors, or that, plasmogamy being effected, karyogamy is inhibited. The work of Ames favors the former proposal.

SUMMARY

Intensive studies of 208 single-ascospore mycelia of *Hypomyces Ipomoeae* have shown each to be self-sterile and to fall into one or the other of two reaction groups. Members of each reaction-group are sterile when mated *inter se*, and react with only one of the two tester-strains bearing opposite sexual-reaction factors. All matings of members of one group with members of the other group have proved fertile.

All single-spore mycelia produce sterile bodies which are with reason assumed to bear the female sex organs. Nearly all such bodies in compatible matings develop into fertile perithecia.

Microconidia of members of either reaction-group appear to be capable of "spermatizing" the female sex organs of members of the other reaction-group.

It is proposed that each single-ascospore mycelium is hermaphroditic, but self-sterile. Each monoploid nucleus must, then, possess the potentialities of both sexes. Hence, sexual-reaction factors, rather than sex factors or sex chromosomes as such, are segregated at meiosis. The data strongly suggest that a single allelomorphic pair is concerned.

DIVISION OF PLANT PATHOLOGY,
UNIVERSITY OF CALIFORNIA,
BERKELEY, CALIFORNIA

LITERATURE CITED

1. Ames, L. M. An hermaphroditic self-sterile but cross-fertile condition in *Pleurage anserina*. Bull. Torrey Club 59: 341-345. 1932.
2. —. Hermaphroditism involving self-sterility and cross-fertility in the Ascomycete *Pleurage anserina*. Mycologia 26: 392-414. 1934.
3. Blochwitz, A. Die angebliche Diökie (Heterothallie) von *Citromyces luteus* und Bastardierungsversuche mit *Penicillium*. Beih. Bot. Centralbl. II 51: 229-302. 1933.
4. Buisman, C. *Ceratostomella Ulmi*, de geslachtelijke vorm van *Graphium Ulmi* Schwarz. Tijdschr. over Plantenziekten 38: 1-5. 1932.
5. Colson, B. The morphology and cytology of *Neurospora tetrasperma*. Ann. Bot. 48: 211-224. 1934.
6. Correns, C. Die Bestimmung und Vererbung des Geschlechts nach neuen Versuchen mit höheren Pflanzen. Berlin. 1907. 81 pp.
7. —. Geschlechtsverteilung und Geschlechtsbestimmung bei Pflanzen. Handwörterb. Naturw. Jena 4: 975-989. 1913.
8. Dade, H. A. *Ceratostomella paradoxa*, the perfect stage of *Thielaviopsis paradoxa*. Trans. Brit. Myc. Soc. 13: 184-194. 1928.
9. Davis, R. J. Studies on *Ophiobolus graminis* Sacc. and the take-all disease of wheat. Jour. Agr. Res. 31: 801-825. 1925.
10. Derx, H. G. L'heterothallie dans le genre *Penicillium* (Note préliminaire). Bull. Soc. Myc. Fr. 41: 375-381. 1925.
11. Dickinson, S. The nature of saltation in *Fusarium* and *Helminthosporium*. Minn. Agr. Exp. Sta. Tech. Bull. 88: 3-39. 1932.
12. Dodge, B. O. The life-history of *Ascobolus magnificus*. Origin of the ascocarp from two strains. Mycologia 12: 115-134. 1920.
13. —. Breeding albinistic strains of the *Monilia* bread mold. Mycologia 22: 9-37. 1930.
14. —. The non-sexual and the sexual functions of microconidia of *Neurospora*. Bull. Torrey Club 59: 347-360. 1932.

15. —. A recessive lethal factor for ascospore formation in *Neurospora*. Ibid. 62: 117-128. 1935.
16. Dowding, E. S. The sexuality of the normal, giant, and dwarf spores of *Pleurage anserina* (Ces.) Kuntze. Ann. Bot. 45: 1-14. 1931.
17. Drayton, F. L. The sexual function of microconidia in certain Discomycetes. Mycologia 24: 345-348. 1932.
18. —. Sexual mechanism of *Sclerotinia Gladioli*. Ibid. 26: 46-71. 1934.
19. Edgerton, C. W. Plus and minus strains in the genus *Glomerella*. Am. Jour. Bot. 1: 244-254. 1914.
20. Gregor, M. J. F. A study of heterothallism in *Ceratostomella pluriannulata*. Ann. Myc. 30: 1-9. 1932.
21. Hansen, H. N. & Smith, R. E. The mechanism of variation in imperfect fungi: *Botrytis cinerea*. Phytopath. 22: 953-964. 1932.
22. Hartmann, M. Verteilung, Bestimmung und Vererbung des Geschlechts bei den Protisten und Thallophyten. Handbuch der Vererbungswiss. 2: 1-105. 1929.
23. Hüttig, W. Die Sexualität bei *Glomerella Lycopersici* Krüger und ihre Vererbung. Biol. Zentralbl. 55: 75-83. 1935.
24. Kirby, R. S. Heterothallism in *Ophiobolus Cariceti*. Phytopath. 13: 35. 1923.
25. Lindegren, C. C. The genetics of *Neurospora*. V. Self-sterile bisexual heterokaryons. Jour. Gen. 28: 425-435. 1934.
26. Shear, C. L. & Dodge, B. O. Life-histories and heterothallism of the red bread mold fungi of the *Monilia sitophila* group. Jour. Agr. Res. 34: 1019-1042. 1927.
27. Wettstein, F. von. Künstliche haploide Parthenogenese bei *Vaucheria* und die geschlechtliche Tendenz ihrer Keimzellen. Ber. Deuts. Bot. Ges. 38: 260-266. 1920.
28. Wineland, G. O. The production in culture of the ascigerous stage of *Fusarium moniliforme*. Phytopath. 13: 51. 1923.
29. —. An ascigerous stage and synonymy for *Fusarium moniliforme*. Jour. Agr. Res. 58: 909-922. 1924.
30. Yarwood, C. E. Heterothallism of sunflower powdery mildew. Science 82: 417-418. 1935.
31. Zickler, H. Genetische Untersuchungen an einem heterothallischen Askomyzeten (*Bombardia lunata* nov. spec.). Planta (Arch. Wiss. Bot.) 22: 573-613. 1934.
32. Zyla, H. Über *Hypomyces rosellus*. Zentralbl. Bakt. II 92: 449-458. 1935.

SEPTOTINIA, A NEW GENUS OF THE CIBORIOIDEAE¹

H. H. WHETZEL

(WITH 18 FIGURES)

The subfamily Ciborioideae of the Helotiaceae embraces a well-marked group of discomycetous fungi the species of which are commonly referred to the genera *Ciboria* and *Sclerotinia*. Nannfeldt (1932: 307) includes in this group the two above-named genera and *Monilinia*, established by Honey (1928) for species having a moniloid conidial stage, which he thus segregates from *Sclerotinia*.

Among the many species commonly referred to *Ciboria* or *Sclerotinia* are several other groups having well-marked generic characters which warrant their segregation under new generic names, for example those species having a conidial stage of the *Botrytis cinerea* type. The genus to be described in this paper is characterized by a type of conidial fructification heretofore entirely unsuspected as belonging to an apothecial fungus. The apothecial stage, here for the first time reported, is typical of the Ciborioideae.² But one species of this genus is at present known to the author.

¹ This is the fourth paper in the series of studies on the North American species of *Sclerotinia* and related genera (*Mycologia* 18: 224; 21: 5; 28: Nov.-Dec.).

Acknowledgments. The writer is under special obligations to Dr. John Dearnness for his generous permission to publish his manuscript notes on the conidial stage of this species. He is indebted to Miss Cynthia Westcott for her assistance in the preliminary studies on this fungus, to Miss Ruby Rice for the drawings and other help in completing the manuscript, and to Mr. R. W. Fisher for taking the photographs. Much of the preliminary work embodied in this paper was done on a grant from the Heckscher Foundation for the Advancement of Research at Cornell University. Its completion has been made possible by a grant from the Penrose Fund of the American Philosophical Society.

² The writer presented a preliminary report on this fungus at the first annual meeting of the Mycological Society of America at Atlantic City in December 1930. Neither the paper nor an abstract of it was published.

While on a visit to Swarthmore College on May 1, 1927, the writer collected a number of minute apothecia (FIG. 1) of the Ciborioideae type, growing from slender, flat, black sclerotia in the soil and leafmold under rapidly expanding plants of *Podophyllum peltatum*. Ascosporic sowings on potato dextrose agar gave cultures which in about two weeks produced a number of more or less circular, thin, flat, black sclerotia on the surface of the media. On a second visit to the same spot, about five weeks later (June 4), it was discovered that the leaves in this patch of *Podophyllum* were generally and severely infected with a fungus producing very large, circular, hydrotic lesions (FIG. 8).

It was at once suspected that these lesions were the result of ascosporic inoculation from the apothecia discovered early in May.

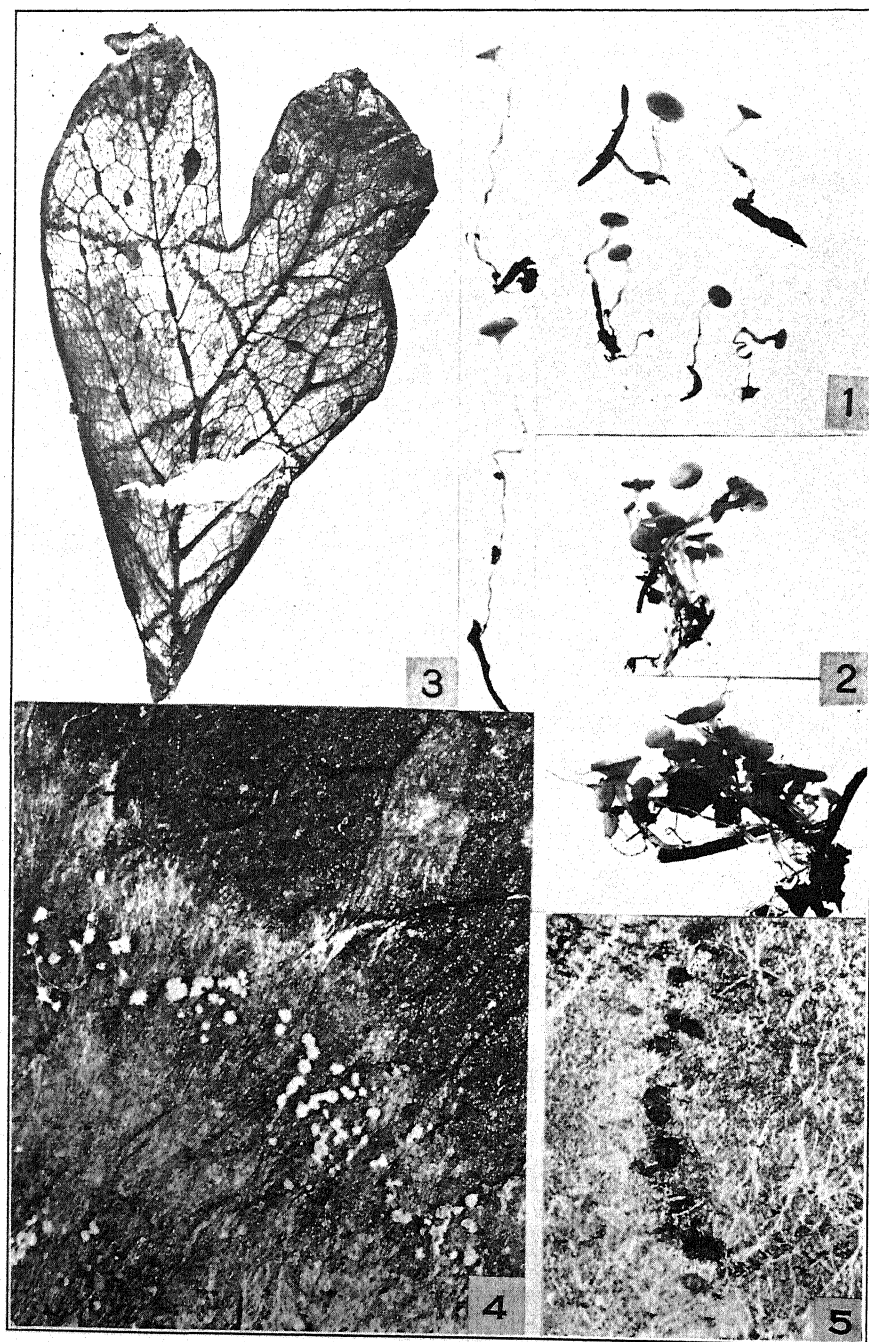
Examination with the hand lens showed minute white sporodochia of a conidial stage scattered over both sides of the lesions (FIG. 4, 7). Tissue plantings from the advancing margins of active lesions, and conidial dilution-cultures, on potato dextrose agar, gave cultures identical in all respects with the ascosporic sowings on the same medium which had been made from the collection of apothecia of May 1. Diseased leaves placed in a moist chamber on wet filter paper rapidly rotted with abundant development of sclerotia, especially along the veins (FIG. 3). These were slender, flat, angular, and pointed like those from which the apothecia developed, occasionally circular, like those produced in culture. Disinfested with calcium hypochlorite and planted on potato dextrose agar, these sclerotia promptly gave cultures identical with the cultures from ascosporic sowings, tissue plantings and conidial dilution-cultures. Sclerotia produced from mass ascosporic sowings on potato dextrose agar slants and held on moist sand at 15° C. produced apothecia in nine months. When held at room temperature apothecia developed in four months. Repeated isolations from ascospores, tissue plantings, conidia and sclerotia from specimens collected in this and other localities, since the spring of 1927, have established beyond question the genetic relationship of the apothecial and conidial stages.

IDENTITY

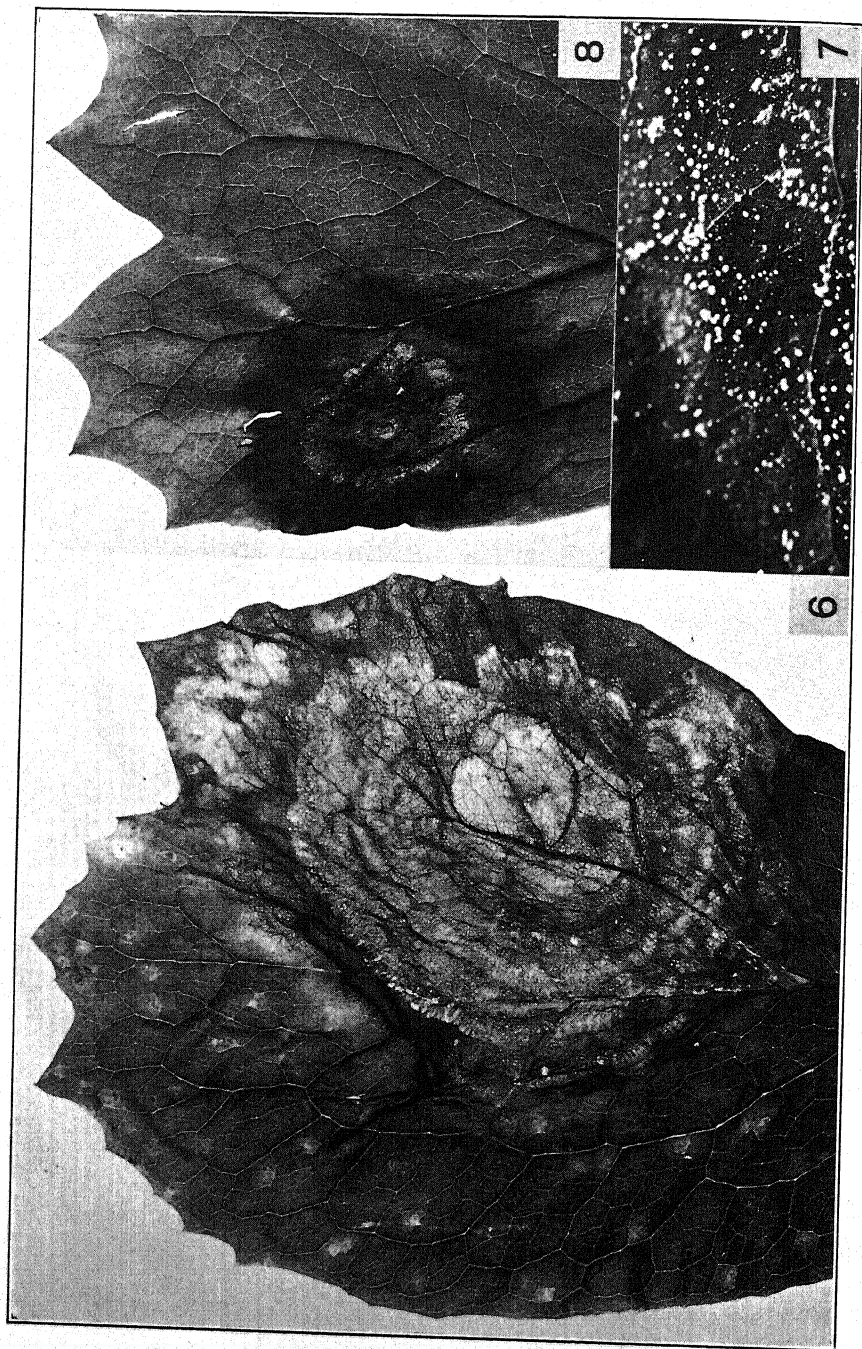
The identity of the fungus was first disclosed when some specimens of the conidial stage freshly collected at Swarthmore, Pa., May 17, 1929, were taken to the herbarium of the United States Department of Agriculture at Washington, D. C., where attention was called by Dr. Vera K. Charles and Dr. W. W. Diehl to the collection of *Gloeosporium podophyllum* Ellis & Ever. (N. Am. Fungi 2442). A careful microscopic examination showed our fungus to be the same as that in this specimen.

The first collection of this fungus appears to have been that made by the Rev. C. H. Demetrio (his number 157) at Concordia, Mo., in May, 1888, to which specimen alone reference is made by Ellis (1888: 103) in his original description of the species. This specimen of the conidial stage is now in the Mycological Herbarium of The New York Botanical Garden. Saccardo (1892: 497) transferred the species to the genus *Septogloeum* because of the septate character of the conidia. The fungus has been distributed in two exsiccati, viz. Rabenhorst-Pazschke, Fungi Europaei 4286, collected by Demetrio at Emma, Mo., June, 1888; and in Ellis and Everhart, North American Fungi 2442, collected by Demetrio at Concordia, Mo., 1889.

Some work on the conidial stage of this fungus by the veteran Canadian mycologist, John Dearness, deserves consideration. In some lists of fungi published by Dearness (1926) he refers this fungus, on p. 66, to *Gloeosporium podophyllum* Ellis & Ev. On page 71 of the same paper he refers it to *Septogloeum podophyllum* (Ellis & Ever.) Sacc., with the interesting remark, "A *Septoriopsis*." Correspondence with Dearness discloses that this reference of the fungus in the same paper to two different genera was an oversight due to his not having seen the proof of this paper before it went to press. His suggestion that it is "A *Septoriopsis*" foreshadowed an unpublished paper he had in manuscript as the result of his studies on specimens sent him by Burnham from Fort Ann, N. Y., in June, 1920. The paper by Stevens and Dalbey (1919) suggested to Dearness that this fungus fell in the genus *Septoriopsis* there established. Petrak's (1924) emended description of the genus *Septogloeum* excluding forms like this on



FIGS. 1-5. *Septotinia podophyllina*.



FIGS. 6-8. *Septotinia podophyllina*.

Podophyllum, having raised in Dearness' mind certain questions which he wished to examine in the light of a personal acquaintance with the fungus in the field, he decided to delay publication. The manuscript still remained unpublished at the time (July 29, 1932) I first wrote him inquiring as to the occurrence of the fungus in Canada. As a result of our correspondence Mr. Dearness sent me a copy of this manuscript which, with his permission, is presented below:

"**Septoriopsis podophyllina** (Ellis & Ev.) comb. nov.

"Syn. *Gloeosporium podophyllum* Ellis & Ev. Jour. Myc. 4: 103. 1888.

"*Septogloeum podophyllum* (Ellis & Ev.) Sacc. Syll. Fung. 10: 497. 1892.

"Ersic. Ellis & Ev. N. Am. Fungi 2442; Rabenh.-Paz. 4286.

"'On light brown (1 cm.) spots with a darker greenish border. Acervuli amphigenous, white erumpent. Spores variable in size and shape, ovate, $12-15 \times 5-7$ microns or oblong and cylindrical, straight or curved, hyaline, 1-3 septate, $20-35 \times 4-7$ microns'—l. c.

"Mr. Burnham's collection affords all the features of the original description and warrants the following additions and modifications. Spots 1 cm., subcircular, irregularly extending to 5 cm., bordered and often more or less concentrically zoned with dark green, translucent and plainly showing the acervuli when observed from either side but erumpent mostly in the upper surface. Tubercles or 'dochia' of short-celled (or up to 60 microns) plectenchyma, either subcuticular or superficial and bearing conidia in all stages of development, continuous and up to 4- or more-septate, attaining a length of 54 microns or more and width of 7 microns and tending to break up. Some of the carpa might very well pass for *Phleospora*.

"On *Podophyllum peltatum* L. West Ft. Ann, N. Y.; June, 1920. S. H. Burnham 366 (D. 1163)." ³

Dearness' suggestion (above) that this conidial stage may fall in the form-genus *Phleospora* (Wallroth 1833) is not tenable since

³ This collection by Burnham is now deposited in the Plant Path. Herb. Cornell University under the number 21043.

the conidiophores of fungi in *Phleospora* are said to be simple. In our fungus they are commonly branched.

This fungus has certain characters which might seem to warrant its reference to the genus *Septoriopsis* of Stevens and Dalbey, which they place in the Tuberculariaceae-Scolecosporae of the Hyphomycetes (Moniliales-Scolecosporae, according to Clements and Shear [1931: 399]). It should be pointed out that it cannot be referred to the genus *Septoriopsis* established by Fragosa and Paul (Fragosa 1915) since this is a genus of the Sphaeriales. Moreover, since the establishment of the genus *Septoriopsis* by Fragosa and Paul antedates that of Stevens and Dalbey, the name is untenable for the genus concept of the latter authors. This is pointed out by Petrak (1925: 69), who proposes the name *Cerco-septoria* for Stevens and Dalbey's genus. The conidiophores in that genus are simple and unbranched, and the conidia narrow and multi-septate. The much-branched character of the conidiophores and the broad, apically attenuated shape of spores of *S. podophyllinum* seem to clearly exclude its conidial stage from this genus; nor can it be referred to *Septogloeum* as emended by Petrak (1924). Since the perfect stage of this fungus has now been discovered, and since it is almost certain that the conidial forms referred by Stevens and Dalbey to their genus *Septoriopsis* are not congeneric with that of our species, there appears to be no valid grounds in the present case for erecting a new form-genus for the conidial stage of our fungus.

TECHNICAL DESCRIPTION

*Septotinia*⁴ gen. nov.

Conidia hyaline, elongate, septate, borne on branched, hyaline conidiophores massed to form a typical sporodochium.

Sclerotia angular, elongate or circular, thin, black, formed in the invaded tissues of the affected plant parts, usually after they have fallen to the ground.

⁴In adopting the name *Septotinia* for the fungus on *Podophyllum*, the writer does not intend to convey the idea of generic relationship with the form-genus *Septogloeum*, but merely to suggest the septate character of the conidia. He is aware of the hybrid etymology of this word, but coins it thus for its euphony and implications.

Spermatia⁵ (microconidia) ovate, very minute, produced on short, Indian club-shaped spermatophores, clustered to form minute spermadochia on the decaying tissues; accompanying formation of sclerotia.

Apothecia shallow, cup-shaped, stipitate, arising in the spring from sclerotia in the soil or leafmold. Asci slender, cylindrical; ascospores hyaline, ovoid; paraphyses simple or branched, tips swollen.

Septotinia podophyllina (Ellis & Ev.) comb. nov.

Syn. *Glocosporium podophyllum* Ellis & Ev. Jour. Myc. 4: 103. 1888.

Septogloeum podophyllum Sacc. Syll. Fung. 10: 497. 1892.

Conidia hyaline, elongate, 0-4-septate, straight or curved, often breaking apart at the septa when mature, truncate at the base, attenuated toward the apex, very variable in length, about 6μ in width (FIG. 13),⁶ borne on branched, hyaline, septate conidiophores

| No. | No. measd. | No. cells | Limits | Average | Mode |
|-------|------------|-----------|----------------------------|-------------------|-------------------|
| S1219 | 7 | 1 | 12.5-22.5 \times 5.0-7.5 | 17.5 \times 5.7 | 17.5 \times 5.0 |
| | 55 | 2 | 17.5-40.0 \times 5.0-7.5 | 24.5 \times 5.9 | 25.0 \times 6.3 |
| | 33 | 3 | 20.0-37.5 \times 5.0-7.5 | 30.5 \times 6.1 | 32.5 \times 6.3 |
| | 5 | 4 | 35.0-45.0 \times 5.0-6.3 | 41.0 \times 6.0 | 42.5 \times 6.3 |

⁵ Since the so-called microconidia of the Discomycetes as well as those of the Pyrenomycetes and lichen fungi doubtless function in fertilization (Drayton 1932, 1934; Ames 1934; Dodge 1932, 1936; and Bachmann 1912, 1913), the writer proposes to revert to the original appellation for these cells, *viz.*, *spermatia* (Tulasne 1852: 157; 1861: 181). Furthermore when, as in this case, the spermatial fruit-body consists of a naked cushion or cluster of spermatophores, it will be designated as a *spermadochium* to distinguish it from the thecal type to which Tulasne (1852: 157) originally applied the term *spermagonium*, the form of spermatial fruit-body usually characteristic of the lichen fungi and the Pyrenomycetes. This terminology is to be preferred to "microconidia" and its derivatives in spite of the fact, as shown by Brierly (1918) and Dodge (1932), that the spermatia in some forms and under certain conditions may germinate and function as true conidia. Ames' (1934) use of "antheridium" to designate the spermatophores is of doubtful validity since the spermatia are apparently not endogenously produced.

⁶ The following table shows the approximate proportion of 1-, 2-, 3-, and 4-celled conidia with their respective measurements in a random sampling of 100 conidia from the type collection, No. 25277.

(FIG. 12) which are densely clustered to form minute, white, mucilaginous sporodochia (FIG. 11), which become horny and often amber-colored when dry. Sporodochia gregarious or scattered over either or both sides of leaf lesions (FIG. 4, 7); usually most numerous on the upper surface, arising beneath the cuticle from the large hyphae of the rhizomorphic, fibrillose, fan-like radiations of the subcuticular mycelium.

Sclerotia formed in invaded tissues of the dead leaves (FIG. 3) and stalks on the ground, most commonly along the veins; including remnants of the tissue embedded in the white medulla (FIG. 10); angular, elongate, or circular, thin, black, 3–5 mm. long by 1 mm. broad.

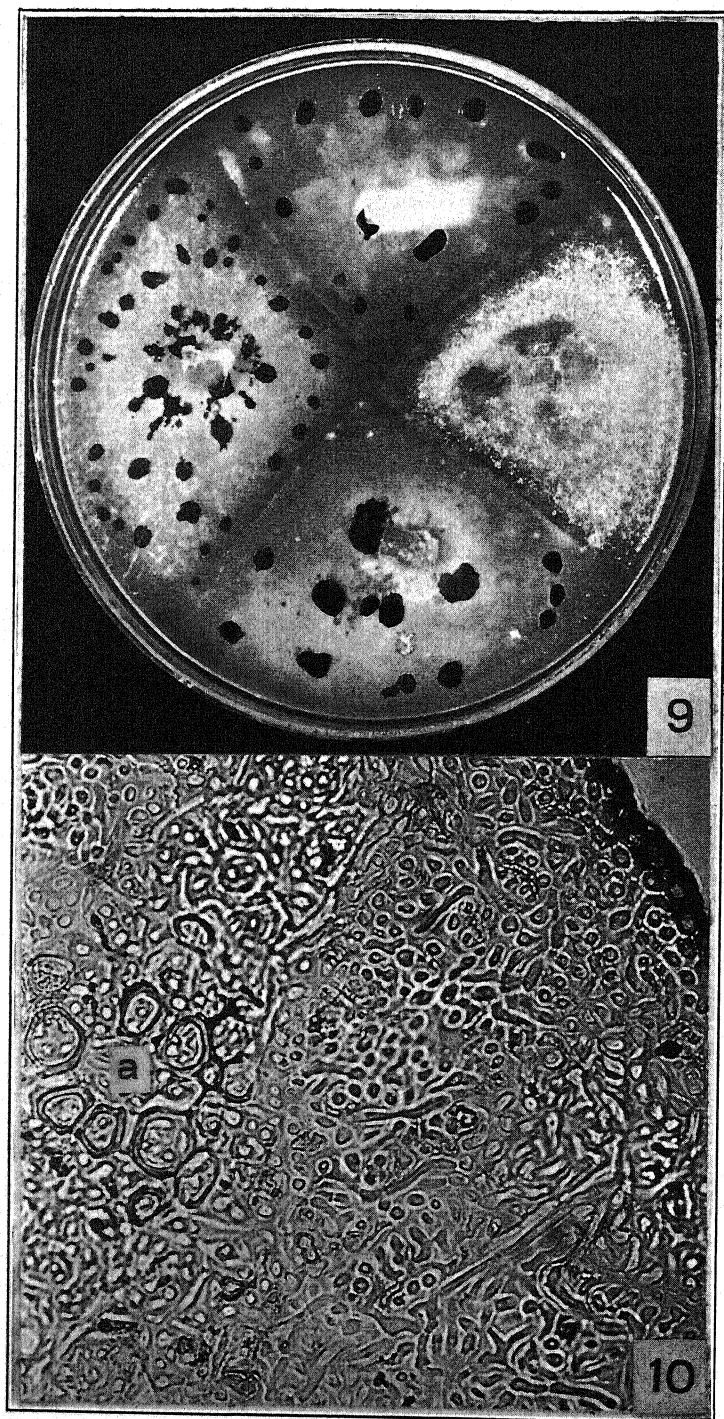
Spermatia accompanying the formation of sclerotia; minute, ovate, $2.4\text{--}3.6 \times 1.5\text{--}2.1 \mu$, average $2.7 \times 2.1 \mu$, mode $3 \times 2.1 \mu$,⁷ with a short stalk or collar, hyaline; produced successively from the tips of densely clustered Indian club-shaped spermatophores, which form minute (almost microscopic), subcuticular, amber-colored spermadochia on the decaying leaf tissues (FIG. 5). Spermatia often remaining in long chains enclosed in a hyaline gelatinous sheath (FIG. 18).

Apothecia shallow, cup-shaped, stipitate, arising from sclerotia on or in the soil or leafmold (FIG. 1, 2); cups 1–4 mm. broad, of a pale fawn color (R); stipe tapering from the cup downward, smooth, concolorous with the apothecium. Asci (FIG. 16) 8-spored, slender, cylindrical, apical plug staining blue with iodine. Measurements of 25 asci of the type specimen, No. 25277, gave limits of $116\text{--}148 \times 7.5\text{--}10 \mu$, average $127 \times 8.8 \mu$, mode $130 \times 8.4 \mu$. Ascospores ovoid, hyaline, 1-celled (FIG. 16); measurements of 50 spores gave limits of $10\text{--}16 \times 5\text{--}6 \mu$, average $13 \times 5.6 \mu$, mode $12.5 \times 5.6 \mu$.⁸ Paraphyses slender, tips irregularly swollen, septate, usually simple, sometimes branched (FIG. 16).

Growing readily on potato dextrose agar where some strains are usually chromogenic, staining the medium cadmium-yellow to raw sienna (R), forming pruinose, floccose or tufted aerial my-

⁷ Measurements of 100 spermatia from potato dextrose culture of single conidial isolate of the type specimen, No. 25277.

⁸ Fifty measurements from each of 5 other collections gave ascus lengths somewhat greater, $120\text{--}160 \mu$, but of the same width as the type. Ascus measurements often vary greatly in different collections of the same species in the Ciborioideae. One hundred measurements from each of these same collections gave ascospore measurements almost identical with those found in the type specimen.



FIGS. 9-10. *Septolinia podophyllina*.

celium, circular, thin, flat, black sclerotia, and spermatia. Optimum temperature for growth and sclerotial production 18–24° C. The conidial stage is pathogenic to leaves of *Podophyllum peltatum* in eastern North America. Known from New York, New Jersey, Delaware, Pennsylvania, Maryland, West Virginia and Missouri.

HERBARIUM MATERIAL. Type specimen No. 25277 is deposited in the Plant Path. Herb. Cornell University (sclerotial, apothecial and conidial stages). Duplicate material from this same collection has been deposited in the following herbaria: Harvard University; New York Botanical Garden; Royal Botanical Gardens, Kew; British Museum, London; Museum d'Histoire Naturelle, Paris; University of Upsala, Sweden; University of Toronto, Canada; University of Copenhagen, Denmark; Mycological Collections, Bu. Pl. Ind., Washington, D. C.; State Museum, Albany, N. Y.; and Missouri Botanical Garden, St. Louis, Mo.

Prior to the beginnings of the writer's studies on this fungus in May, 1927 (apothecial collection No. 15602), he had incidentally made two collections of the conidial stage in the vicinity of Ithaca, N. Y., one at Chicago Pond in July, 1906 (No. 2439), and another at Taughannock Falls, N. Y., June 8, 1910 (No. 23272). There is in the Atkinson (general collection) herbarium at Cornell University an unnumbered, undated collection by Bertha Stoneman made at Lakewood, N. Y., probably about 1898, under the name "*Gloeosporium* on *Podophyllum*."

In addition to these collections, there are now deposited in the herbarium of the Department of Plant Pathology at Cornell University, eleven collections of the conidial stage and nine of the apothecial stage, made by the writer and others in New York, Pennsylvania and New Jersey.

The only other collections known to the writer, in addition to those cited above in the discussion of the identity of our fungus, are two of the conidial stage in the Mycological Collections, U. S. D. A., Bur. Pl. Ind., Washington, D. C., one made at Morgantown, W. Va., June 21, 1928, and one at Cabin John, Md., June 3, 1930. In his search of herbaria in 1932 for early collections of this fungus, the writer sent specimens of the conidial stage to

a number of mycologists in this country and abroad, which are presumably to be found in their personal or institutional herbaria.

Other collections of the conidial stage are probably to be found in herbaria in this country. That collections of the apothecial stage have been heretofore made and preserved by others than the author is improbable. The writer would greatly appreciate records of any collections not referred to in this paper.

DISTRIBUTION

This fungus appears to be most common in a relatively narrow belt running west from the Atlantic seaboard to Missouri (Latitude 36–43° north). The host, which is a native of eastern North America, occurs from western Quebec and southern Ontario to Minnesota and Kansas, and south to Florida, Louisiana and Texas. As far as the writer has been able to discover, the fungus, which was originally collected (conidial stage) in Missouri in 1888 and again in 1903 (Maneval 1926: 85), has been collected elsewhere only in Pennsylvania, Delaware, Maryland, West Virginia, New Jersey and New York. Our own observations indicate that it is most common here in the East in Pennsylvania and New Jersey. The writer has found it in but few stations in the neighborhood of Ithaca, and there in very limited areas. The most northern collection of which we know is the one made by Burnham on June 12, 1920, at Fort Ann, N. Y., in the upper Hudson River Valley. An extensive survey would probably disclose a more general occurrence of the fungus than the small number of records now indicate. The apothecial stage has been collected apparently thus far only in Pennsylvania, New York and New Jersey, but will doubtless be found where sought at the right time of the year (late April or early May) wherever the conidial stage is known to occur.

CULTURAL CHARACTERS

This fungus grows readily on potato dextrose agar at ordinary room temperatures. The optimum temperature for production of sclerotia appears to be between 18° and 24° C., varying with different isolates. Sclerotia appear in about 14 days at these temperatures.

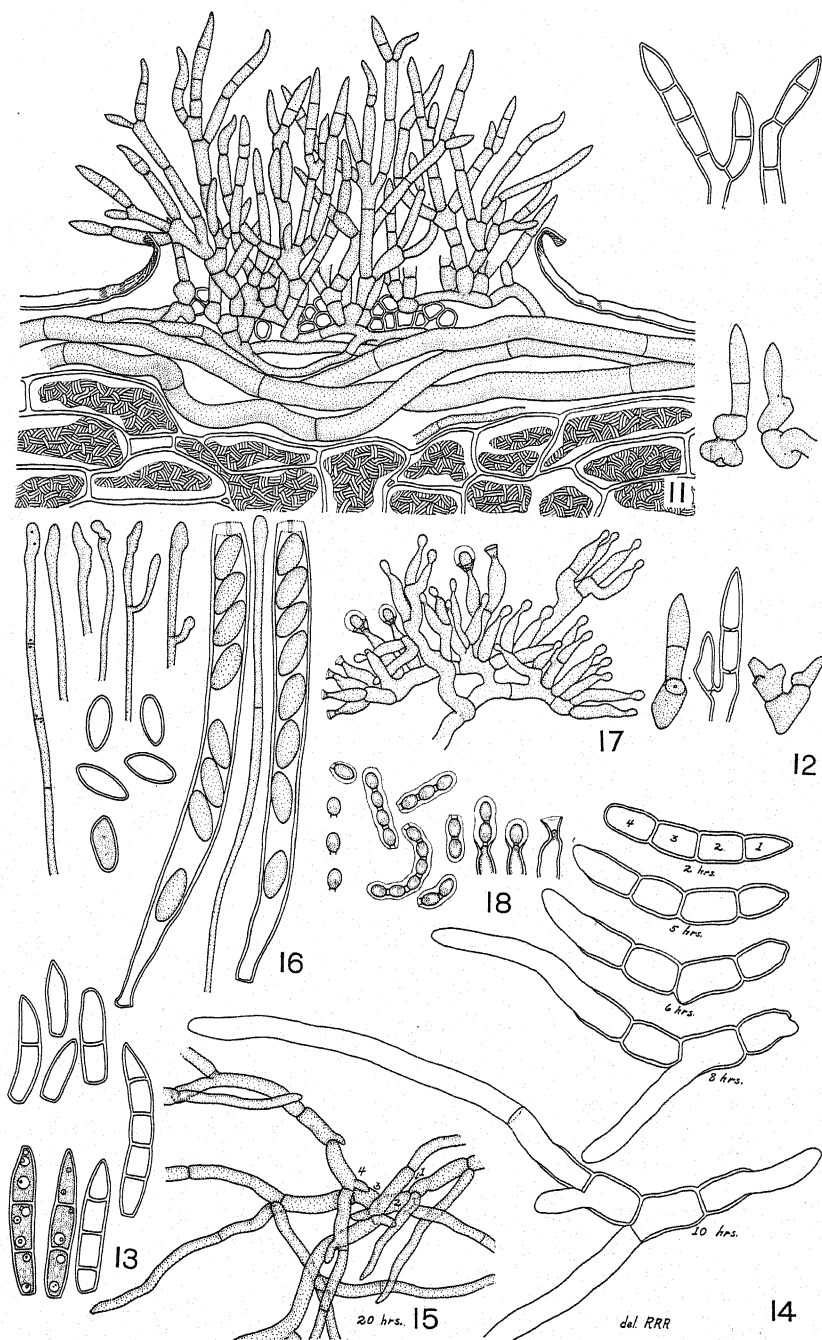
Single ascosporic isolates from any individual ascus give two different types of growth on potato dextrose agar (FIG. 9). For convenience in discussing them, they may be designated plus (+) strains and minus (—) strains. They occur in approximately equal numbers in random samplings.

The + strains are as a rule the more vigorous growers and have a slightly higher optimum temperature for sclerotial production. At 21° to 24° C. aerial mycelium is usually abundant, woolly, floccose or strongly tufted, at first white, eventually collapsing to form a yellowish-brown felt. In petri dish cultures thin, black, crust-like sclerotia, circular, oval or slightly irregular in outline, develop in 10–14 days; sometimes fusing to form large, irregular crust, especially at temperatures just below optimum; usually zonately disposed. Spermatia are present but not abundant. The medium is slowly and slightly or not at all discolored.

The minus strains, usually less vigorous than the plus strains, produce relatively little aerial mycelium, especially in the early days of growth. This is usually pruinose, sometimes with large scattered white tufts, quickly becoming a dark yellowish-brown in color and collapsing to form a dirty-brown felt. The optimum temperature for sclerotial production in most minus strains appears to be 15° to 18° C. Sclerotia are few or entirely wanting at temperatures above or below the optimum. Spermatia are usually abundantly developed. The medium is quickly and strongly discolored by the minus strains; at first of a bright cadmium-yellow, it soon turns to a dirty reddish-brown. The degree of medium-discoloration varies in the different minus isolates and is most pronounced at temperatures above the optimum for sclerotial production. At low temperatures (12°–9° C.) the discoloration usually shows a strong purple tint.

Single conidial isolates likewise give two types of growth on potato dextrose agar which are identical with the plus and minus strains described above. However, the isolates from any given lesion are all alike, either all plus or all minus, as is to be expected since each lesion usually represents a single ascosporic or a single conidial infection.

Mass cultures of ascospores or conidia give various combinations of the above-described characters of the plus and minus



FIGS. 11-18. *Septotinia podophyllina*.

strains, as is of course to be expected. The cultures, especially the minus strains, tend to "run out" (deteriorate or die out) at room temperature after several transfers. The characters above described are for recently isolated (one to two months old) strains. There is considerable individual variation in strains, both plus and minus, from the same apothecium or from a given conidial sporodochium.

This striking segregation of ascosporic and conidial isolates into two groups suggests that this fungus may be self-sterile ("heterothallic" *sic*), cross spermatization between plus and minus strains probably being necessary for production of apothecia from the sclerotia.

Conidial production has never been observed in artificial cultures, either from ascosporic or conidial sowings. Their development of conidia on agar is probably dependent on the proper slow drying of vigorously growing cultures.

PATHOGENICITY

Although no inoculation experiments have been undertaken, the evidence from the isolation work and field observations leaves no question in the writer's mind as to the pathogenetic relationship of this fungus to *Podophyllum*.

The lesions appear to be confined commonly to the leaf blades. They are usually initiated at some point within the margin of the blade, but in some cases at or near the margin itself. In an actively spreading lesion, the center of the necrotic spot is light brown, surrounded by a broad zonate area, the outer advancing zone of which is hydrotic. The margin of the lesion is more or less sharply defined. The mycelium just beneath the upper cuticle of the leaf forms white fans of radiating, rhizomorphic strands, most evident in the zone just back of that of the hydrotic margin (FIG. 4, 6). These whitish, fibrillose hyphal fans are a striking and characteristic feature of the lesions caused by this fungus.

The white conidial sporodochia are scattered over both surfaces of the lesion or gregariously localized here and there where conditions happen to be especially favorable to their development. They are usually most numerous on the upper surface of the lesion.

The leaflet or even the whole leaf may become completely involved and eventually wilt and hang dry and dead from the tip of the petiole.

LIFE HISTORY

When the diseased leaf eventually falls to the ground the fungus continues its vegetative activities in the dead tissues of the lesion, and spreads into the adjacent uninvaded parts of the blade. It now begins the accumulation of reserve foods into slender, angular (occasionally oval or circular), thin, black sclerotia which are formed most commonly along the veins and veinlets within the disintegrating leaves or along the upper third of the stalk. Coincident with the formation of the sclerotia, the spermadochia develop beneath the cuticle of the disintegrating leaves. These appear as minute, nearly microscopic, amber-colored bodies, often arranged in rows across the leaf (FIG. 5). The spermatia are produced in great numbers on these spermadochia in the manner characteristic of species of the Ciborioideae (FIG. 17). They doubtless function in the sexual fertilization necessary to the production of apothecia, as the work of Drayton (1932) on *Sclerotinia Gladioli* has shown. With final disintegration of the leaf tissues the sclerotia become buried in the soil and leafmold, there to remain until the following spring, when they give rise to the apothecia at the time the young leaves of the *Podophyllum* are expanding. Collection records of the apothecia indicate that they usually develop, in the region from Swarthmore, Pa., north to Ithaca, N. Y., from about the middle of April until the middle of May.

The ascospores are forcibly discharged into the air and, falling upon the young leaves when they are moist, germinate and infect them. The limited observations which the writer has made do not warrant a definite pronouncement as to the time elapsing between inoculation and the first evidence of infection. Collection records of the conidial stage indicate that well-developed lesions are abundant in a week or ten days after ascosporic inoculations. The earliest date on which leaf infections have been observed by the writer is May 15, 1936, at Labrador Lake, N. Y., ten days after apothecia in abundance were collected in the same area.

These lesions were so well developed, however, that they must certainly have been evident at least some days earlier.

The conidia doubtless initiate secondary cycles which would account for the actively developing lesions to be found in late June.

NOTES. There are several features of *S. podophyllina* which deserve special notice. The conidial stage is unique in the Ciborioideae, both as to the elongate-septate characters of the conidia and the sporodochial form of the conidial fruit-body. The structure of the sclerotium is typical of that of the botryoid species, the medulla consisting of relatively thin-walled hyphae embedded in a transparent gelatinous or horny matrix (FIG. 10), in contrast with the medulla of the true Sclerotiniaceae (e.g., *S. sclerotiorum*) in which the medulla is made up of densely interwoven, thick-walled hyphae but not embedded in a matrix. The spermatia, while borne on spermatophores of the usual Ciborioideae type, and apparently in the manner described by Brierly (1918) for the spermatia of *Botrytis cinerea*, are markedly ovate instead of globose and present at their basal end a distinct stalk or collar. The gelatinous matrix in which they are embedded is exceptionally persistent, tending to hold the spermatia together in long chains even in water mounts (FIG. 18).

There is in the Herbarium of The New York Botanical Garden a specimen of a fungus on the ripening fruits of *Podophyllum peltatum*, collected by A. Commons (his number 598) at Faulkland, Del., Aug. 8, 1887, the original label of which bears the name "*Gloeosporium fructigenum* B.?" Ellis, to whom the specimen was referred, added the note, "*Gloeosporium podophyllum* E. & E. var. *fructigenum* E. & E. Spores broader than in *G. fructigenum*." A careful examination of the specimen shows it to be a *Colletotrichum*, setae being present in great abundance. The fungus is quite distinct from the conidial stage of *S. podophyllina*, of which Ellis apparently regarded it a variety. The writer has found no published description of this fungus in the literature under this name. *Septotinia podophyllina* has never been observed on the fruits of its host, lesions apparently occurring only on the leaves and top of the stalk.

LITERATURE CITED

- Ames, L. M. Hermaphroditism involving self-sterility and cross-fertility in the ascomycete *Pleurage anserina*. *Mycologia* 26: 392-414. 1934.
- Bachmann, Freda M. A new type of spermagonium and fertilization in *Collema*. *Ann. Bot.* 103: 747-760. 1912.
- Bachmann, Freda M. The origin and development of the apothecium in *Collema pulposum* (Bernh.) Ach. *Archiv. Zellforsch.* 10: 369-430. 1913.
- Brierly, W. B. X. The microconidia of *Botrytis cinerea*. *Kew Bull.* (1918)⁴: 129-146. 1918.
- Clements, F. E. & Shear, C. L. The genera of fungi, pp. 1-496. 1931.
- Dearness, J. An annotated list of anthracoses. *Canadian Dept. Agr. Bull.* 71: 62-83. 1926.
- Dodge, B. O. Spermatia and nuclear migrations in *Pleurage anserina*. *Mycologia* 28: 284-291. 1936.
- Dodge, B. O. The non-sexual and the sexual function of microconidia of *Neurospora*. *Bull. Torrey Club* 59: 347-360. 1932.
- Drayton, F. L. The sexual function of microconidia in certain discomycetes. *Mycologia* 24: 345-348. 1932.
- Drayton, F. L. The sexual mechanism of *Sclerotinia Gladioli*. *Mycologia* 26: 46-72. 1934.
- Ellis, J. B. & Everhart, B. M. *Gloeosporium podophyllum* E. & E. In New species of fungi from various localities. *Jour. Myc.* 4: 103-104. 1888.
- Fragoso, R. G. Hongos parasitos de la florula hispalense, nuevos o poco conocidos. *Bol. Soc. Esp. Hist. Nat.* 15: 120-132. 1915.
- Honey, E. E. The monilioid species of *Sclerotinia*. *Mycologia* 20: 127-157. 1928.
- Maneval, W. E. Parasitic and wood destroying fungi of Boone County, Missouri. *Univ. Missouri Studies* 1: 65-111. 1926.
- Nannfeldt, J. A. Studien über die Morphologie und Systematik der nicht-lichenisierten inoperculaten Discomyceten. *Nova Acta Soc. Upsal.* IV 8²: 1-368. 1932.
- Petrak, F. Ueber die Gattung *Septogloeum* Sacc. In *Mykologische Notizen*. *Ann. Myc.* 22: 168-169. 1924.
- Petrak, F. Ueber die Gattung *Septoriopsis*. In *Mykologische Notizen* VIII. *Ann. Myc.* 23: 68-70. 1925.
- Saccardo, P. A. *Septogloeum podophyllum* (E. & E.) Sacc. *Syll. Fung.* 10: 497. 1892.
- Stevens, F. L. & Dalbey, Nora E. New or noteworthy Porto Rican fungi. *Mycologia* 11: 4-9. 1919. (*Septoriopsis*, p. 4.)
- Tulasne, L. R. Des spermogonies. In *Memoire a l'histoire organographique et physiologique des lichens*. *Ann. Sci. Nat.* III. 17: 153-159. 1852.
- Tulasne, L. R. & C. On the controversy about the sex of fungi. In *Selecta Fungorum Carpologia* 1: 181. 1861. (Grove's Transl. 1: 182-184. 1931.)

Wallroth, F. G. 171. *Phleospora* W. Fl. Crypt. Germ. 2: 176-177. 1833.

EXPLANATION OF FIGURES

Fig. 1, individual apothecia attached to sclerotia; twice natural size; 2, clusters of apothecia as they occur where sclerotia are abundant on the ground; twice natural size; 3, sclerotia in rotting leaf; natural size; 4, conidial sporodochia on upper surface of leaf just back of the advancing margin of fan-like mycelium in the lesion; ten times natural size; 5, spermadochia beneath cuticle in rotting leaf; nine times natural size; 6, top view of lesion in leaf; note fan-like mycelium just back of advancing margin of lesion; natural size; 7, conidial sporodochia on upper surface of leaf; twice natural size; 8, top view of young lesion in leaf; natural size; 9, plantings of four single ascospore isolates on potato dextrose agar, grown at 24° C., 27 days old; the sector on the right is a typical minus strain; note absence of sclerotia and heavy aerial mycelium; medium strongly discolored a deep cadmium yellow; natural size; 10, freehand section through a sclerotium from leaf of the type collection, 25277; note the embedded xylem vessels of leaf veins at *a*; enlarged 462 times; 11, a semi-diagrammatic longisection through a conidial sporodochium which originates just beneath the cuticle; magnification about $\times 300$; 12, details of formation of conidiophores and conidia; magnification about $\times 550$; 13, showing different forms, sizes and septation of conidia, with contents detailed in two of them; magnification about $\times 550$; 14, showing progressive stages in the germination of a four-celled conidium at room temperature; cells numbered from apical to basal cell; magnification about $\times 550$; 15, showing mycelial development from spore detailed in figure 14, 20 hours after beginning of germination; magnification about $\times 300$; 16, showing details of asci, paraphyses and ascospores; magnification about 550; 17, semi-diagrammatic longisection through a spermadochium; magnification about $\times 850$; 18, details of spermatia and spermatial formation; magnification about $\times 850$.

NOTES AND BRIEF ARTICLES

G. R. Bisby, of the University of Manitoba, has left to take a position at the Imperial Mycological Institute, Kew, Surrey, England, beginning January 1, 1937.

THE PERFECT STAGE OF THE SOUR ORANGE SCAB FUNGUS

The perfect stage of *Sphaceloma Fawcetti* Jenkins, the causal fungus of citrus scab, has recently been discovered on rind of Satsuma orange (*Citrus nobilis unshiu* Sw.) in São Paulo, Brazil, and is described in *Phytopathology* 26: 393-396, 1936, as *Elsinoe Fawcetti* Bitancourt and Jenkins.

Three important mycological papers have recently appeared in the *Studies in Natural History of the University of Iowa*: "Notes on the Lower Basidiomycetes" by Donald P. Rogers; "The Gasteromycetes of Iowa" by Paul E. Kambly and Robert E. Lee; and "A Key to the Families of Fungi Exclusive of the Lichens" by G. W. Martin. The latter is very convenient since it represents a concise treatment of the families of fungi. It also contains a glossary of some of the important mycological terms. Any of these papers can be obtained by addressing the Department of Botany, State University of Iowa.

CITRUS DISEASES AND THEIR CONTROL

A second edition of this authoritative work on the citrus diseases of the world has been published by the McGraw-Hill Company. The book has been completely revised and re-written by Prof. H. S. Fawcett, of the University of California, thus permitting the presentation of the abundance of new information in this field which has accumulated during the ten years that have elapsed since the appearance of the first edition. The inclusion of this new material has necessitated a very considerable enlargement of the book to 656 pages even though a number of illustrations used in

the original edition have been deleted. New sections have been added dealing with water rot, areolate spot, hard rot, Macrophomina root rot, red root disease, Ganoderma root rot, and a number of other new diseases. A new chapter on diseases due to deficiency and excess of inorganic constituents was written in collaboration with Dr. A. R. C. Haas. New sections on sweet-orange fruit scab, Australian citrus scab, and areolate spot were prepared in collaboration with Dr. Anna E. Jenkins. An outstanding feature is the comprehensive bibliography covering 42 pages which is more than double the space devoted to this feature in the first edition.—J. A. STEVENSON.

NOTE ON CONIDIOBOLUS

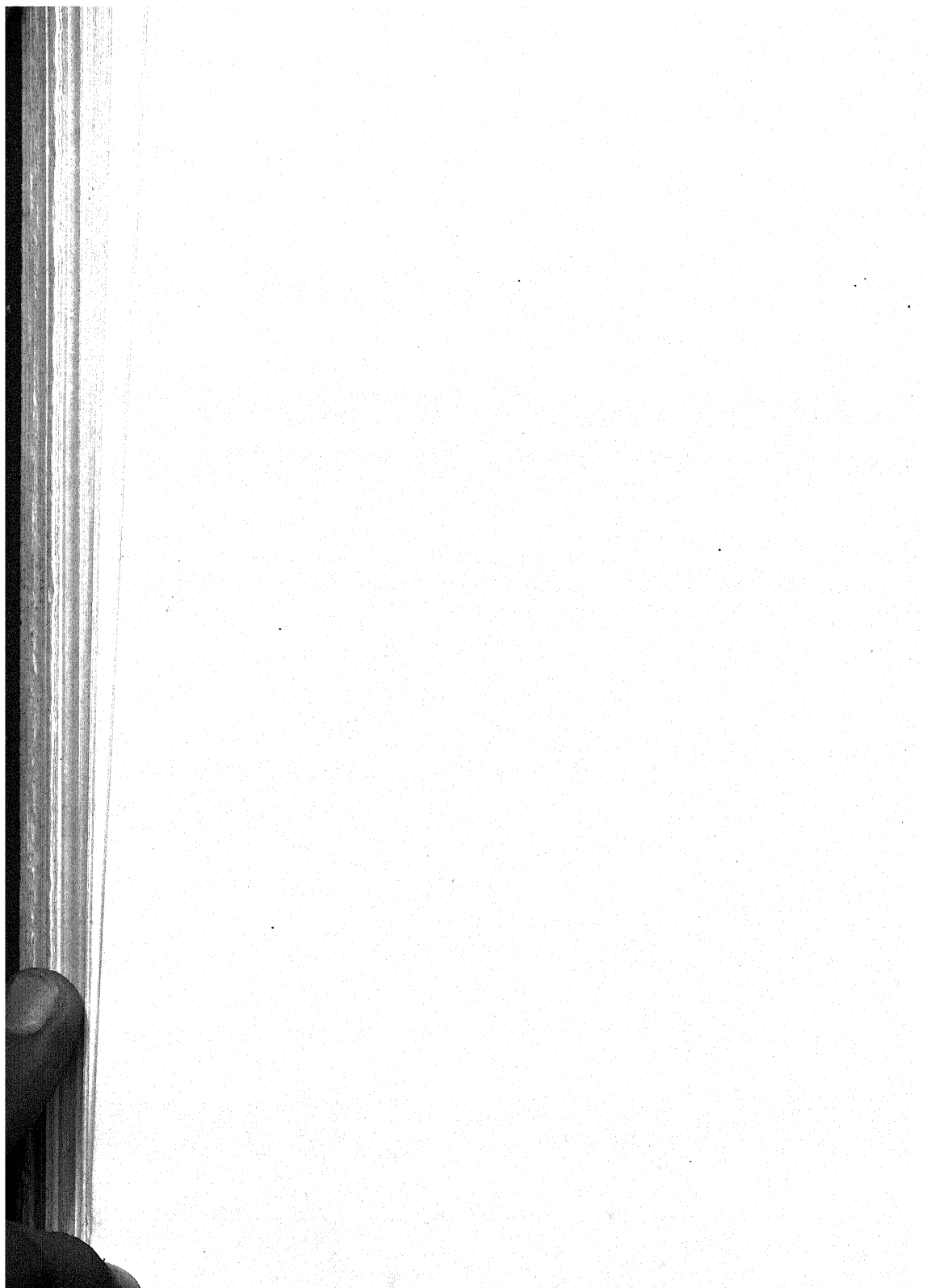
The appearance of *Conidiobolus villosus* Martin as a petri dish contaminant in the mycological laboratories at Cornell University seems worthy of mention here because of the evident rarity of the species and its association with a new substrate in a new locality. The species was described from Iowa by Martin (Bot. Gaz. 80: 311-318. 1925) after it had appeared on a plate of agar during an attempt to secure a species of *Hypochnus* in pure culture. So far as the writer is aware there has been no further report of the species since the original publication.

On August 9 several apothecia of *Peziza domiciliana* Cooke, found in a cellar in Ithaca, were brought into the laboratory by a fellow student, E. W. Lyle. A portion of one of these was fastened to the lid of a petri dish over potato dextrose agar to obtain a spore shooting. Examination on the third day showed the area on which the ascospores had fallen to be overgrown by the contaminating organism, with a thin dusting of conidia on the lid about the bit of apothecium lying directly over this area. Growth of the *Conidiobolus* was rapid, and in a few days the inside of the cover of the dish was thoroughly dusted with white conidia. A second attempt to obtain a culture of the *Peziza* from apothecia collected in the same cellar a week later met with similar results.

The organism corresponds with Martin's fungus in being positively phototropic. Also it is in close agreement in all features of morphology, including size of the conidia and the transformation

of some of them into appendaged resting spores, which seem to be the chief characteristics of the species. Aside from the fact that the diminished average size of conidia in aged cultures—in some cases as low as 18μ —is more marked than Martin's discussion would seem to imply, measurement of several hundred of them under various conditions furnishes no occasion for the recording of dimensions other than those which he gives.—W. L. WHITE.

At the annual summer conference of advisory plant pathologists at Leeds University, Dr. Geo. H. Pethybridge, Mycologist to the Ministry of Agriculture and Fisheries for the last twelve years, and previously for many years in the Department of Agriculture in Ireland, was—by over seventy present and former colleagues—presented with a wireless receiving set etc. as a mark of appreciation on the occasion of his approaching retirement from official service.—W. BUDDIN.



MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOL. XXIX

MARCH-APRIL, 1937

No. 2

THE NUCLEAR HISTORY OF SCLEROSPORA GRAMINICOLA¹

E. S. McDONOUGH²

(WITH 2 FIGURES)

INTRODUCTION

Recently Hiura (5), Tasugi (19), and Evans and Harrar (4) showed with certainty the method of germination of the oöspores of *Sclerospora graminicola* (Sacc.) Schröt. This achievement made it possible to study critically for the first time the nuclear stages following the resting period of the oöspore. However, before this study had advanced very far it became apparent that it would also prove profitable to rework the stages in oögenesis covered by Stevens (17) and Ruhland (13, 14) some two decades ago.

REVIEW OF PREVIOUS INVESTIGATIONS

The members of the Albuginaceae which have been studied cytologically were divided by Stevens (16) into three groups ac-

¹ A portion of a thesis submitted to the faculty of the Graduate College, Iowa State College, in partial fulfillment of the requirements for the degree, doctor of philosophy.

² The author wishes to acknowledge his indebtedness to Dr. J. E. Sass under whose direction this investigation was carried out and to Dr. I. E. Melhus who suggested the problem and who has given many valuable suggestions during the course of the work. He also wishes to express his appreciation to other members of the Botany Department of Iowa State College, and to Dr. W. N. Steil of Marquette University, Milwaukee, Wisconsin, for many helpful suggestions.

[MYCOLOGIA for January-February (29: 1-149) was issued
February 1, 1937]

according to their nuclear history preceding the origin of the oöspore. As originally described by Stevens (15, 16) and recently verified by Tsang (20), the nuclei in the oögonium as well as those in the antheridium of *Albugo Bliti* (Biv.) Kuntze and *A. Portulacae* (D. C.) Kuntze undergo two successive divisions simultaneously. The nuclei in the periplasm, however, do not undergo the second division. About 100 nuclei enter the oögonium from the antheridium and fuse in pairs with the nuclei in the oösphere. The fusion nuclei remain without dividing until the oöspore is mature.

In *Albugo Tragopogonis*, according to Stevens (16), a multinucleate oösphere develops, the nuclear history being similar to that of *A. Bliti*. However, the oösphere is then reduced to the uninucleate condition by disorganization of nuclei. One or more antheridial nuclei enter the oösphere and one fuses with the functional female nucleus. The fusion nucleus undergoes repeated mitoses, and the winter oöspore is consequently multinucleate.

Albugo candida (Pers.) Kuntze (3, 16, 20, 22) belongs to a third group in which two divisions of nuclei take place in both antheridium and oögonium and after the second division in the oöplasm all the nuclei except one are described as passing into the periplasm. Only one nucleus enters the oögonium from the antheridium. The nucleus resulting from the fusion of the two sexual nuclei undergoes several mitoses so that about 32 nuclei are found in the mature oöspore.

The members of the genus *Peronospora*, as exemplified by *Peronospora effusa* (1, 20), and the members of the genus *Plasmopara*, as exemplified by *Plasmopara alpina* (12), are similar in their nuclear history to *Albugo candida*. However, in *Peronospora* the fusion of the sexual nuclei takes place slowly and the mature oöspore contains the fusion nucleus. In *Plasmopara* the mature oöspore also contains the fusion nucleus. Another interesting feature in this* genus is the small amount of periplasm formed.

While the reports of Ruhland (13, 14) and Stevens (17) on the development of *Sclerospora graminicola* are in close accord on most points, they differ with respect to important features. Stevens reports that the mitoses of all the nuclei in the young oögonium are closely simultaneous and that mitosis may proceed

until metaphase before there is any sign of differentiation into periplasm and oöplasm. When metaphase is reached the nuclei are found arranged approximately in a circle around the region that is to become the oösphere. Only one nucleus remains behind with the coenocentrum. In *Sclerospora graminicola* the coenocentrum is merely a dense mass of cytoplasm in the center of the oögonium, differentiated into two regions of different density. One of the nuclei produced by the division of the single nucleus which remains in the oöplasm wanders toward the periplasm leaving the female pronucleus near the coenocentrum. According to Ruhland, all nuclei in the young oögonium divide at the same time and after the second and following divisions, which take place near the periphery of the oögonium, a single female nucleus leaves the periplasm and enters the oösphere. This solitary nucleus remains in the oösphere and undergoes a mitosis previous to the entrance of the male nucleus. Ruhland reports one division of the nuclei in the antheridium.

Meiosis has been reported as taking place at various points in the life-cycle of members of the Peronosporales. Wager (21, 22, 23) did not observe meiosis during the development of the sex organs, but believed that the nuclei found in the mature oöspore of *Albugo candida* might undergo reduction in chromosome number. Stevens (15) in his early study on *Albugo Bliti* observed 12 chromosomes at some anaphases and six at others during the two divisions of the nuclei in the developing oögonium. Because of this he believed that meiosis might take place at this point. In his later paper (16) he was uncertain as to the position of meiosis in the life-cycle of the species of *Albugo* studied. However, in this report Stevens (16) states that the difference in character between the first and second mitosis may be due to a change in kinoplasmic content. Davis (3) was unable to observe meiosis in the development of the sex organs and the mature oöspore of *Albugo candida*. Krüger (10) reported from 14 to 16 chromosomes in the dividing nuclei of the oögonium and antheridium of *A. candida* and *Peronospora Ficariae*. All divisions taking place in these organs were described as equational in nature up to the time when fertilization took place. Since he observed 16 chromosomes in the nuclei formed after the first division of the fusion

nucleus, he considered that meiosis took place during the division of the fusion nucleus. Tsang (20) believed that the decrease in the quantity of chromatin during the first division in the oögonium had led some investigators to infer that reduction in chromosome number took place at the same time. In *Albugo candida* and *A. Tragopogonis* Tsang observed the number of chromosomes at the first anaphase of the fusion nucleus to be greater in number than at the second anaphase. The number of chromosomes at the equatorial plate of the first division was believed by Tsang to be 24. After the first two divisions the number was observed to be about 12.

METHODS AND MATERIALS

Leaves of *Setaria viridis* containing developing oögonia of *Sclerospora* were collected and fixed in August, 1932, at Ames, Iowa, and in September, 1934, near Milwaukee, Wisconsin. Some of these leaves were green and others were just turning brown. This material was fixed in Flemming's medium fluid, Bouin's picro-formal, formalin acetic alcohol, chromo-acetic solution, or a solution made up of 75 ml. of one per cent acetic acid, 20 ml. of one per cent chromic acid, and 5 ml. of 37 per cent formaldehyde. Ethyl alcohol, acetone, and butyl alcohol were tested as dehydrating agents in preparation for embedding in paraffin. Material dehydrated with butyl alcohol was the easiest to cut. Cross or longitudinal sections 5 to 10 microns thick were made and stained with Flemming's triple stain, iron haematoxylin, brazilin, or crystal-violet-iodine. The same general methods were used in the preparation of germinating oöspores for microscopical study.

Oöspore material used in studies of the nuclear aspects of oöspore germination was collected and germinated at different times during the years 1932 to 1936. The method used in germinating oöspores was essentially that described by Hiura (6) and was found to be the most convenient of the several tried. Petri dishes were lined with absorbent cotton which had been moistened in sterile distilled water. The oöspores to be germinated were placed on the cotton in the lower part of the Petri dish.

OBSERVATIONS

Development of the oögonium and the antheridium. Early stages in the development of the oögonium in *Sclerospora graminicola* were found to be similar to those described for *Albugo* by Istvanffi (9), Wager (22), and Stevens (15). The oögonium was observed to be the swollen end of a hypha, but in exceptional cases it was intercalary. The young oögonium was filled with cytoplasm and nuclei at the expense of the hypha to which it was attached. The entrance of the protoplasm was apparently rapid since a number of striae were observed in the cytoplasm and the nuclei were elongated in the direction of flow (FIG. 1: 1). At the time of entrance of the nuclei into the oögonium they were crumpled in appearance, such as has been generally described for members of the Peronosporales. Counts in serial sections of 24 young, but apparently fully expanded, oögonia indicated that from 49 to 71 nuclei had entered. Shortly after the expansion had been completed, a septum was observed to have closed the oögonium and the oögonial wall to have thickened at all points except where the antheridium was attached.

The nuclei in the oögonium were found to have increased greatly in size (FIG. 1: 2). The number of enlarged nuclei was found to range between 16 and 24 in counts based on 32 oögonia. These nuclei simultaneously pass into prophase and reach metaphase, a stage which may last, as Stevens has also reported, until differentiation into oöplasm and periplasm has begun to take place. At this point, however, no continuous membrane separates the oöplasm and periplasm, and typically all except one of the nuclei become oriented on the boundary between these regions (FIG. 1: 3). This account agrees with that of Stevens in that one nucleus is reported as remaining in the oöplasm, whereas Ruhland reports all the nuclei as migrating to the periplasm and later one nucleus entering the oöplasm.

During the expansion of the nuclei just described, there appears in the center of the oögonium a dense mass of cytoplasm which gradually increases in bulk. This body, which has been called the coenocentrum by Stevens, is, in *Sclerospora*, merely a dense mass of cytoplasm with radiating strands. One of the nuclei, which

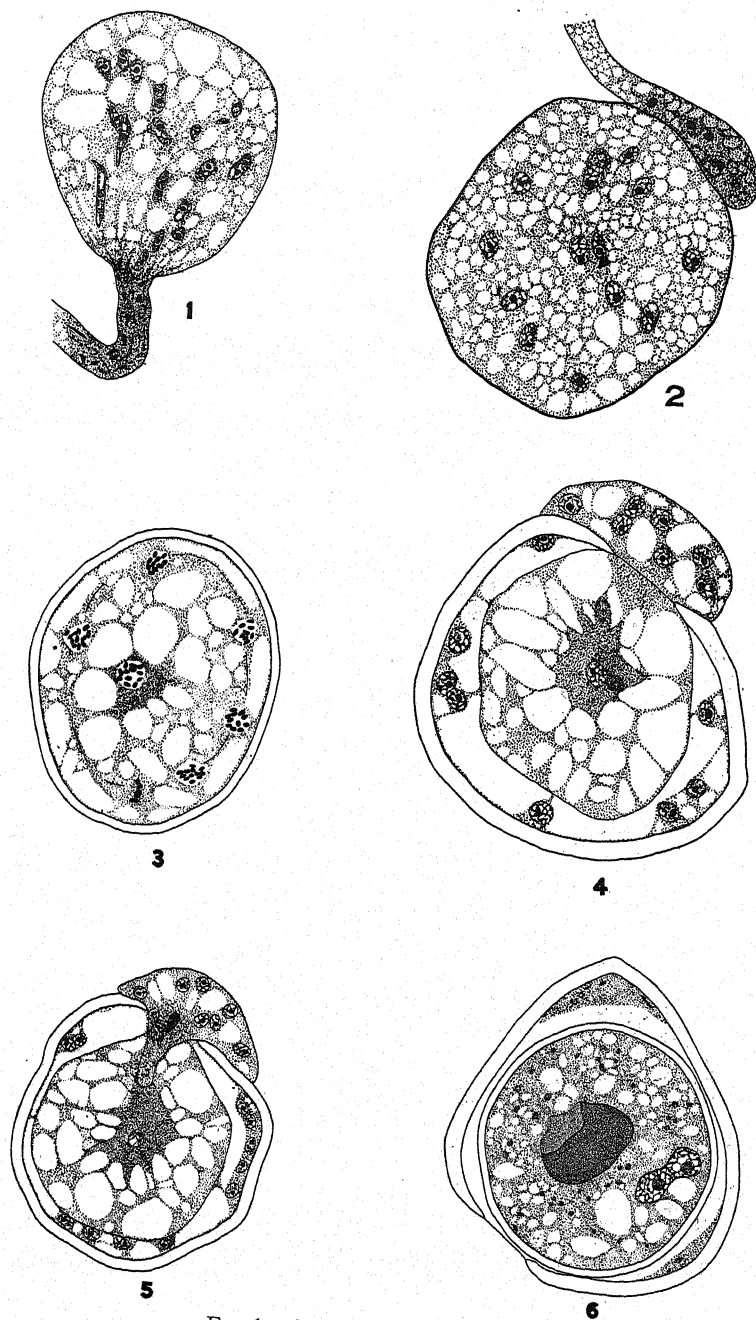


FIG. 1. *Sclerospora graminicola*.

remains close to the coenocentrum, undergoes division. One of the resulting daughter nuclei was commonly difficult to see because it may be imbedded in the coenocentrum (FIG. 1: 4).

All of the nuclei in the oögonium undergo simultaneous mitosis and the resulting nuclei enter a short resting stage, after which most, or all of them, divide again. The second divisions may not all take place at the same time. It was not unusual to find nuclei in various stages of the second mitosis. Ruhland reported the nuclei in the oögonium as undergoing several divisions, but Stevens reported only one division of the oögonial nuclei. Figure 2: 6 is interesting in this connection in that four late prophase nuclei are observed in the oöplasm. Such a figure could be explained by assuming that one nucleus has remained behind in the oöplasm and that two divisions have already taken place. Another explanation would assume that two nuclei remained in the oöplasm and have divided once and are about to undergo the second division. Further evidence that the oögonial nuclei divide at least twice is to be found in counts of nuclei made at the time of entrance of the nucleus from the antheridium. Such counts in 29 oögonia ranged from 49 to 92 nuclei. Soon after the oögonial nuclei have ceased to divide, all except one degenerate or migrate into the periplasm, the single functional female nucleus becoming imbedded in the coenocentrum.

Those nuclei which occupy the peripheral region of the oögonium have the axes of their mitotic spindles parallel to a tangent of the oögonium so that the resulting daughter nuclei do not enter the oöplasm. The nucleus remaining near the coenocentrum divides in such a way that one daughter nucleus remains in the coenocentrum.

As has been previously stated, there does not seem to be a typical simultaneous second mitosis of the nuclei since these older oögonia commonly contain nuclei in various stages of division. The second and subsequent divisions, if more than two divisions do occur, of the nuclei in the oögonium do not seem to differ in any essential way from the first mitosis. There is, however, a decided difference in the size of the chromosomes present at metaphase of the first and second divisions (FIG. 2: 4, 8). There is also a

difference in the size of the nuclei and the division figures (FIG. 2: 10, 11).

The nature of the mitoses which take place in the developing sex organs was studied in detail. The early stages in the development of the nuclei in the young oögonium were masked by their crumpled appearance. However, these nuclei soon were observed to have increased in size and were spherical in outline. The prophase shown in figure 2: 7 was similar to that of the higher plants and other fungi. As the chromatin aggregated to form the prophase chromosomes the nucleolus disappeared. In metaphase the chromosomes were clearly distinguishable. Figure 2: 8 shows 14 chromosomes present in the first mitosis in the oögonium. These chromosomes were rather small, the larger being about one micron in length and it was possible to miss the smaller chromosomes, consequently counts were difficult to make. It would seem, however, that there were not less than 14 nor more than 16 chromosomes present at this stage. The spindle was intranuclear (FIG. 2: 9) and pointed, ending in a body which stained more deeply than the surrounding cytoplasm and which might be considered to be a centrosome. This body did not, however, show in all preparations.

At anaphase the chromosomes were somewhat attenuated but the X and Y chromosomes described by Ruhland (FIG. 2: 10) were not recognized. It would seem that most or all of the chromosomes had terminal attachments. At telophase the chromosomes gradually lost their identity.

The antheridium became attached to the oögonium at a very early stage and contained at first three or four nuclei. The first mitosis preceded that of the oögonial nuclei so that by the end of the first prophase in the oögonium, the nuclei in the antheridium had already divided.

While Ruhland (14) reported one division of the nuclei in the antheridium, the present study seems to show that two mitoses took place. Anaphase nuclei in the antheridium at late prophase of the first oögonial division were found to be three to four in number. Eleven cases were observed in which six to eight nuclei were present in the antheridium at a slightly later stage. Mature antheridia at the time of fertilization were found to possess from 8 to 16

nuclei. These counts would seem to indicate that there were two mitoses in the antheridium.

The mitoses taking place in the antheridium were similar to those taking place in the oögonium. About 14 chromosomes were found at metaphase of both divisions (FIG. 2: 4).

Fertilization and development of the oöspore. At the point of attachment of the antheridium to the oögonium the wall of the latter remained thin. It was often impossible to distinguish between the walls of the two sex organs since they were both thin and firmly pressed together (FIG. 1: 4). Careful observation failed to demonstrate a bulging of the periplasm into the antheridium previous to the entrance of the antheridial tube into the oögonium. The projection produced in this way, the "receptive papilla" of Wager (22) which has been found in many members of the Peronosporales, may not be produced in *Sclerospora* or it may be very temporary in nature.

After the nuclei have ceased to divide in both of the sex organs, there may be several nuclei near the coenocentrum. However, just previous to the entrance of the conjugation tube, the oöplasm became uninucleate. Since no degenerating nuclei were observed at this stage, it is assumed that the nuclei in the oöplasm, other than the pronucleus, migrated to the periplasm. Figures suggesting this were observed and Stevens (17) also reported such a migration as taking place. At this stage, which is just previous to the entrance of the nucleus from the antheridium, no instance was observed where more than one nucleus was present in the oöplasm. Likewise, since "zonation," or the differentiation of the oöplasm and periplasm, takes place in *Sclerospora* rather slowly, it would be possible for nuclei to migrate from one region to another.

Shortly after zonation began, the oöplasm was displaced from the center of the oögonium toward the side to which the antheridium was attached. The oöplasm was in contact with the wall of the oögonium at a later stage (FIG. 1: 4), at which time the oösphere was surrounded by a definite membrane which Stevens called the plasmoderm.

The conjugation tube was assumed to have entered the oögonium by rupturing the thin oögonial wall. The tube apparently penetrated rapidly into the oösphere and grew some distance into the

öoplasm before it ruptured (FIG. 2: 3). Figure 1: 5 shows the penetration of the conjugation tube to approximately its greatest extent.

As shown in figure 1: 5 the conjugation tube had entered well within the öosphere before the nucleus had left the antheridium. The male pronucleus was elongated and somewhat pointed at the time of its entrance into the tube. After the nucleus had traveled the length of the conjugation tube the latter burst open allowing the nucleus as well as some cytoplasm from the antheridium to enter the öosphere. After its liberation from the tube the male pronucleus became spherical and penetrated directly into the dense mass of cytoplasm in which the female pronucleus was imbedded. Only one nucleus has been observed to enter into the öogonium from the antheridium.

The subsequent history of the conjugation tube was somewhat vague but it could be seen in the öoplasm for some time after the antheridial nucleus had entered. Apparently the tube degenerates and most of it is absorbed by the cytoplasm of the öosphere.

At first the nucleus from the antheridium was slightly smaller than the female pronucleus. However, the former soon reached the same size as the latter. In *Sclerospora* the two nuclei which ultimately fused increased in size until they were considerably larger than they were before the initial steps of fertilization took place. The sexual nuclei left the coenocentrum as that body began to disappear and the nuclei became separated some distance from each other. Nuclear fusion was delayed for a considerable time, many changes taking place in the öosphere after the entrance of the nucleus from the antheridium and previous to karyogamy.

The wall of the öospore began to differentiate after the nucleus had entered from the antheridium. This wall was observed to be formed as a secretion of the öoplasm. During this process there might be seen directly inside the developing wall a narrow band of small granules. The wall so formed was composed of two layers, a very thin and smooth outer layer, the exospore, and a much thicker layer, the endospore. These were not easily distinguished from each other. It could thus be seen that the wall of the öospore in *Sclerospora* was very simple when compared with that of such fungi as *Albugo candida*, in which Stevens (16) and

Tsang (20) have described the exospore as elaborate in nature and arising from the periplasm. While it is possible that the periplasm may play some part in the formation of the exospore in *Sclerospora*, this would seem unlikely since the periplasm is very much limited in extent and degenerates quickly after fertilization has taken place. Another possibility is that *Sclerospora* does not have an exospore comparable to that of *Albugo*, but that the two layers of the wall are comparable to the two layers of the endospore of *Albugo* and the thickened wall of the oögonium may be considered to be the exospore. During the formation of the wall of the oöspore, the wall of the oögonium became wrinkled and came into contact with the oöspore at several places.

As indicated in figure 1: 6 the oöspore may have developed almost to maturity before the sexual nuclei fused. The fusion took place between resting nuclei, and no instance was observed of the fusion taking place between nuclei containing chromosomes as was reported by Berlèse (1) for *Peronospora alsinearum* and *P. effusa*. The two nuclei came into contact with each other and their membranes dissolved away at the point of contact. The reticulum of one nucleus seemed to become continuous with that of the other. Some figures indicated that the nucleolus of the male pronucleus fused with that of the male. Such a phenomenon has also been reported for *Peronospora effusa* by Tsang (20). Ultimately the fusion nucleus contained but one nucleolus.

It was always possible during the course of this investigation to find binucleate oöspores which were apparently mature, judging from the condition of the central body and the oöspore walls. Since no trace of a division of the fusion nucleus was ever observed before the oöspores were placed in conditions under which they germinated, it would seem that plasmogamy might be so delayed that the mature oöspore was in some instances binucleate. However, the fusion of nuclei is normally so gradual that all functional oöspores may contain a fusion nucleus. On the other hand, among ripe oöspores, which had been soaked for six hours in a soil extract, some were found to contain stages which were identical with those of the fusion nucleus observed during the development of the oöspore. It is difficult to be certain that oöspores in which the nuclei seem to fuse after the resting period actually

germinate. However, oöspores of the same material which were fixed 12 hours later did not have nuclei which exhibited fusion stages. It would seem possible that the fusion of the sexual nuclei may in some instances be so delayed that it takes place after the resting period has been ended.

The disintegration of the antheridium started soon after fertilization and antheridia were seldom found to be present on mature oöspores. During the development of the oöspore wall the supernumerary nuclei in the oögonium began to degenerate along with the rest of the periplasm. However, it was possible to observe these nuclei after the oöspore was well developed.

Directly after the entrance of the male pronucleus, there appeared in the cytoplasm of the oöspore many small bodies which stained only slightly with any of the dyes used. As the oöspore matured these bodies became more numerous and increased in size. Eventually they coalesced in the center of the oöspore to form a central body. This body (FIG. 1: 6) which became large, completely replacing the coenocentrum, has been described by Wager (22) in the case of *Albugo candida* as being formed by the accumulation of oil drops. Tsang (20) considered this body to consist of several substances, such as metachromatin, albuminoids, phenolitic compounds, and oils. During the course of this investigation it was observed that the body in question as found in *Sclerospora graminicola* turned black with osmic acid. However, when the spores were crushed and treated with Sudan III the central body failed to give the red stain reaction characteristic of fats. In some spores containing several bodies which had evidently not as yet fused to form the large body, it was found that certain of these globules turned red with Sudan III. Even oöspores collected in the field contained globules of oil in the cytoplasm as was shown by their reaction to Sudan III and a solution of alcannin in 50 per cent alcohol. It would therefore seem that the material in question is not a typical fat.

General features of oöspore germination. Previous to the production of the germ tube, many changes took place in the oöspore. One of the most conspicuous of these was the gradual digestion of the large central body. The gross features of this phenomenon may be followed in living material but its critical details could be

seen only in stained sections. The central body seemed to have a firm, semi-solid texture. At first this body was essentially homogeneous except that it might possess a few vacuoles which contained a substance apparently of a less viscous nature. One of the first evidences of oöspore germination visible in sectioned material was the initial step in the digestion of the central body. Soon after the spores had been placed on moist cotton under the proper conditions for germination, it was observed that small pits were formed at the periphery of the central body. These pits led from the outside and extended into the mass of stored material in such a way as to produce a spongy appearance. As the germination continued these pits became larger. Eventually the pits merged and in many instances the entire body was divided into several pieces. In other cases the digestion took place more rapidly on one side than on the other. In such cases the central body presented the outline of a crescent. Ultimately, usually before the germ tube was formed, the oöspore became free of all remnants of the central body.

As has been previously shown, the oöspore is rich in oil, even in the resting condition. Tests made with Sudan III and alcannin indicated that as the central body disappeared the amount of oil in the spore increased. Germinated oöspores which had produced germ tubes were tested for oil in the same way. Many rounded oil drops were demonstrated by these tests as being present in the tubes.

Another phenomenon which may be observed in the germination process is the thinning of the wall of the oöspore. When the spore is in the resting condition this wall has been found to have an average thickness of four microns, but after the germ tube has been produced the thickness of the wall was found to average less than one micron.

Although Fréchou was reported by Prillieux (11) to have observed the germination of the oöspores of *Sclerospora*, the gross features of the formation of the germ tube was described with certainty by Hiura (5), Tasugi (19), Evans and Harrer (4), Howe (8), Chaudhuri (2), Weston and Uppal (24), and Takasugi and Akaishi (18). Chaudhuri (2) pictured two or more germ tubes emerging from one spore and Hiura (7) mentioned that

two germ tubes might leave the spore through the same opening in the oogonial wall. Oöspores have been germinated at various times during a period of more than four years, but in no case was more than one germ tube seen to emerge from an oöspore. However, it was not uncommon to find that the germ tube had branched immediately after it had emerged from the spore. Germ tubes observed under the conditions of these experiments had invariably penetrated through the thin spot which remained in the wall of the oogonium and which indicated the place at which the antheridium was attached. This thin spot was observed with ease in sections of ripe oöspores. The germ tube was hyaline in the living condition and showed a number of rounded bodies and fine granular cytoplasm.

Nuclear phenomena associated with the germination of the oöspore. During the early stages of the oöspore germination preceding the production of the germ tube, a rapid increase in the size of the nucleolus of the fusion nucleus was observed. Simultaneously with the expansion of the nucleolus, the reticulum became transformed into a mass of fine threads. At this stage (FIG. 2: 12) the average diameter of the fusion nucleus was 7.2 microns. Some indications of pairing of threads were observed, but the threads were so interwoven and so fine that it was very difficult to observe their true relationships. A noticeable feature of this stage was the position of the nucleolus. Although at first it occupied a central position in the nucleus, the nucleolus was later observed to take up a position near to, or touching, the nuclear membrane. Such figures, which were not uncommon in these early stages (FIG. 2: 12), strongly suggest the "bouquet" stage.

After the transformation of the reticulum into the thin threads of the early prophase there followed a gradual contraction of these threads. As this process advanced the visibility of the chromosomes increased until it was possible to pick out individual members of the chromosomal complement. In such stages it was possible to count at least 28 very small chromosomes. The largest chromosomes were about one micron in length; however, with proper staining and selection of filters for microscopic study the number and relationships could be determined. Such chromosomes may be observed to be in pairs. Figure 2: 13 shows the

nucleus in a prophase stage, evidently early diakinesis, exhibiting 14 bivalent chromosomes. Such figures were not uncommon, but because of the small size of the chromosomes and also because of the tendency for the nucleolus to obscure the picture, it was not always possible to make satisfactory counts. There was also a tendency for the smaller members of the complement to be obscured by the larger. Although the association of the bivalents in some instances was seen to be rather loose, in many instances, especially in the earlier stages of diakinesis, the association was close.

The later stages of diakinesis and the metaphase were found to be rather obscure, in part because these stages seemed to be of short duration and also because the large nucleolus obscured the chromosomes. It should be indicated at this point that the formation of the thickened chromosomes during the prophase of the fusion nucleus was not accompanied by a decrease in size of the nucleolus. On the other hand, this body increased in size during the prophase.

The spindle of the first division of the fusion nucleus was intranuclear. No definite centrosomes were observed and it seems likely that they are not present during the divisions of the nuclei in the oöspore. The first indication of the initiation of the anaphase was the elongation of the nucleus. This elongation was usually at right angles to the diameter of the oöspore. The spindle was not very dense and the elongation of the whole nucleus as well as the elongation of the spindle was found to be closely associated with the movement of the chromosomes to the poles. The movement of the chromosomes to the poles was not simultaneous (FIG. 2: 10). Some chromosomes were found to reach the poles before the rest and such figures presented the chromosomes so that they could be easily counted. It was not uncommon to find that one or more of the chromosomes had a decided tendency to lag behind the rest to such an extent that at late anaphase there could be seen quite clearly one or more chromosomes still close to the center of the spindle.

As has previously been stated the chromosomes were rather easy to count at early anaphase. Fourteen chromosomes were observed to go to each pole. However, it was not possible to de-

termine whether each chromosome consisted of two chromatids, nor was it possible to determine the location of the spindle attachments. Throughout the anaphase the chromosomes were observed to be in the shape of rods which at times, however, were lengthened as if they were under stress.

After the majority of the chromosomes had reached the poles of the spindle, the nucleolus began to divide. This division, because of the large size and striking character of the nucleolus, was easy to follow. Simultaneously with this division, the chromosomes began to be attached to each other by means of many fine fibers. As a result of the elongation of the nucleolus and the connecting of the chromosomes by threads, a figure was produced in which the chromosomal material formed two hollow cups in which the ends of the elongated nucleolus were imbedded (FIG. 2: 17). As the elongation of the nucleolus took place, it constricted so as to simulate a dumb-bell. It was possible, by means of the Flemming's triple stain, to stain the nucleolus red and the chromosomal material violet. Such figures presented the appearance of a large dumb-bell capped on each end with a reticulum. After the division of the nucleolus had been completed, the two nucleoli contracted somewhat. The two daughter nuclei were connected for some time by a thread which was evidently the remains of the nuclear membrane of the fusion nucleus. The two nuclei later became separated from one another by some distance (FIG. 2: 18). Subsequently the nuclei became rounded and the reticulum gradually lost its chromaticity.

The division of the two daughter nuclei was similar in its broad outline to the division of the fusion nucleus. The prophase was, however, considerably different. No pairing of chromosomes was observed and the number of chromosomes found at late prophase was 14 (FIG. 2: 15). The nucleolus divided during the division of these nuclei in a manner similar to the first division. Because of the separation of the two daughter nuclei of the fusion nucleus, it was not easy to find both of the second division figures present in the same section.

The third division taking place in the oöspore was similar in all major details to the second division. At late prophase 14 chromosomes were found to be present but this number could not be seen

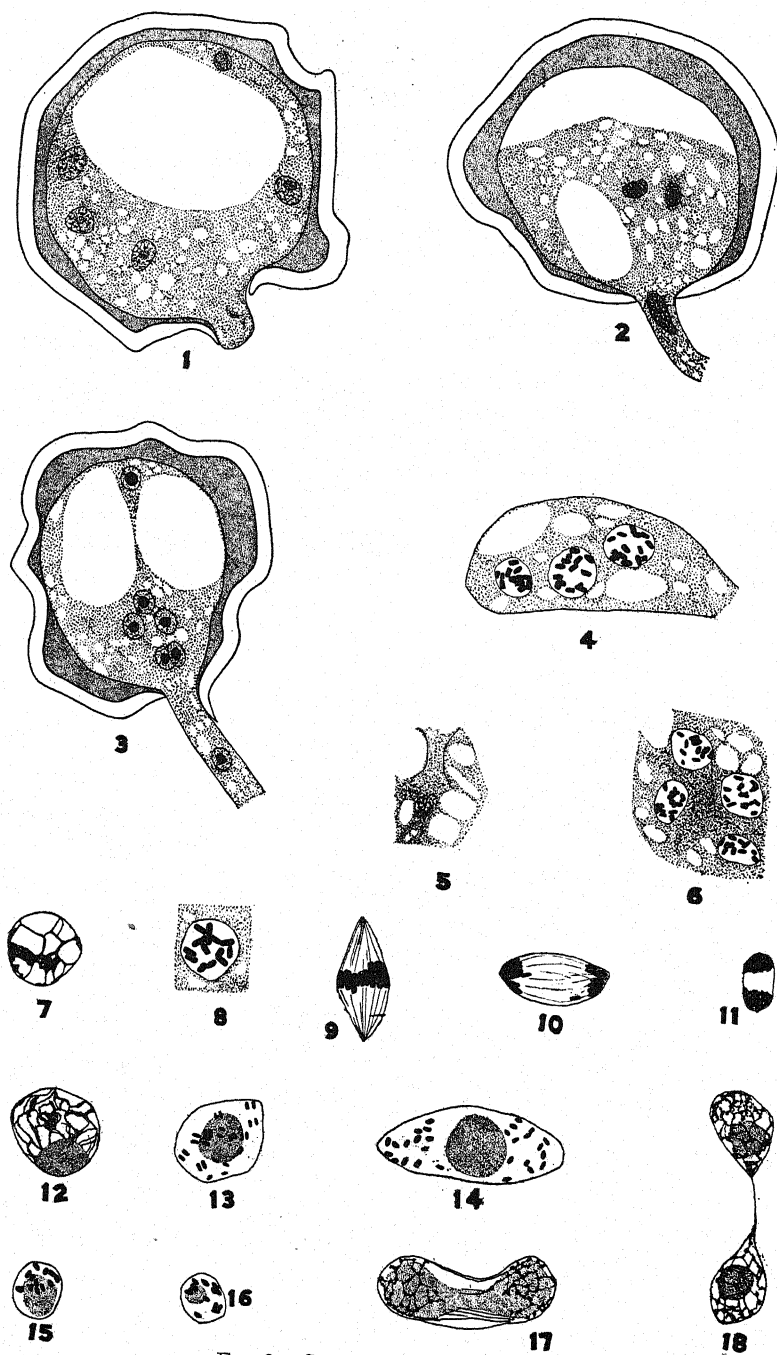


FIG. 2. *Sclerospora graminicola*.

in all nuclei because of the presence of the nucleolus (FIG. 2: 16).

It would seem that as a rule about 32 nuclei are found in the oöspore before it produces the germ tube. The later divisions taking place in the oöspore are apparently identical with the third division, but because of the decrease in size of the nuclei during this series of divisions, it was not possible to determine the character of the nucleolar division. It is possible that after the nucleolus has reached the size found in the mycelium, it disappears with each division of the nucleus in a manner similar to that described above for the nuclei in the oögonium and the antheridium.

After the nuclei had ceased to divide, or in some instances before they had ceased to divide, the wall of the oöspore, which was now thin, protruded at the spot nearest the thin place in the oögonial wall (FIG. 2: 1). After the tube had penetrated through the wall of the oögonium the nuclei began to enter the germ tube. As the nuclei entered they were seen to resemble the male pronucleus in shape (FIG. 2: 2). They were considerably beaked and elongated. In older stages of the formation of the germ tube, more than one of these beaked nuclei might be seen in readiness to enter the tube. Eventually all the nuclei might enter the tube and along with them all the cytoplasm of the oöspore. The nuclei in the germ tube were easily seen because of their conspicuous nucleoli (FIG. 2: 3).

DISCUSSION

While the studies on the development of the oögonium and the antheridium of *Sclerospora graminicola* reported here are in general agreement with those reported by Ruhland (13, 14) and Stevens (17), they differ in certain important respects. While Stevens (17) reported one division of the nuclei in the oögonium, some of these nuclei were observed to undergo two or more divisions, which was in accord with the work of Ruhland (14). Ruhland reported one division of the nuclei in the antheridium, but the present study indicates that there are normally two such divisions.

Ruhland was of the opinion that no coenocentrum was present in the oösphere, but Stevens reported that the coenocentrum resembled that of *Albugo Bliti* except that the central globule was

not observed. Stevens described the coenocentrum found in this species as a dense mass of cytoplasm. Such an accumulation was observed to be present in the oöplasm of the oöspores studied. Its extent was greater than that found by Stevens. The central globule was not observed.

Stevens and Ruhland reported the number of chromosomes present during metaphase of the division in the oögonium to be small. The number observed in the present investigation was typically 14. A certain clumping of the chromosomes was observed at times, but under proper magnification, staining, and illumination the chromosomes could be clearly seen in well preserved material.

The fusion of the nuclei is a slow process in *Sclerospora*. The evidence presented here seemed to indicate that the fusion could take place before or after the resting period. This would place *Sclerospora* in an unique position among the Albuginaceae and Peronosporaceae. However, in *Albugo Bliti*, *Albugo candida*, and *Peronospora effusa* Tsang (20) has shown that there is a tendency for not only a decrease in the number of nuclei which fuse in the oögonium, but also in the rate of fusion. In this scheme *Sclerospora* might well be considered to have carried the process still further so that fusion of the sexual nuclei takes place in the germinating oöspore.

While the divisions of the nuclei in the germinating oöspore were at times obscured by the oil drops and the disintegration of the central body, some preparations were found to be surprisingly clear. While at first the large nucleolus was confusing, it became a helpful guide to a diagnosis of the stage of the germinating oöspore. The divisions of this body were distinct and were seen to be preceded in all cases by the division and migration of the chromosomes to the poles. The gradual decrease in size of the nuclei and the nucleoli during the series of divisions taking place in the oöspore was striking. These divisions took place rapidly and the size of the nucleolus decreased out of proportion to the decrease in size of the nucleus.

While the early stages of the prophase of the fusion nucleus were not as distinct as might be desired, the later stages were sufficiently clear to indicate that the chromosomes had paired.

The anaphase stage of the dividing fusion nucleus showed the haploid number of chromosomes going to each pole. Later divisions of nuclei in the oöspore showed the haploid number of chromosomes. It is, therefore, concluded that meiosis took place during the first two divisions of the fusion nucleus.

SUMMARY

The early stages in the development of the oögonium and the antheridium of *Sclerospora graminicola* were found to be similar to those described for other members of the Peronosporales. A distortion, which was not attributed to poor fixation, was characteristic of nuclei entering the young oögonium. There were at least two divisions of most, if not all, of the nuclei in the oögonium and antheridium. The fusion of the two sexual nuclei took place very slowly, so that they had not yet fused when the oöspore had reached the resting stage. The haploid number of chromosomes was found to be present at metaphase of all mitoses in the developing sex organs.

After the nuclei in the oögonium ceased to divide, all except one were found in the periplasm. The one functional female pronucleus remained within the dark mass of cytoplasm in the center of the oöplasm. The conjugation tube penetrated into the oöplasm and one nucleus left the antheridium, passed through the conjugation tube and into the oöplasm. After the entrance of the male pronucleus, the wall of the oöspore was formed from the oöplasm and at the same time a large central body was formed. In the mature oöspore the wall of the oögonium became wrinkled and came into contact with the wall of the oöspore. The two walls were not observed to have become continuous at any point.

A few hours after the oöspores had been placed in the conditions under which they germinated the fusion nucleus divided. Subsequent divisions followed until the oöspore contained typically about 32 nuclei. At late prophase of the division of the fusion nucleus the chromosomes were seen to be associated in pairs. At anaphase the haploid number of chromosomes was found to go to each pole. Late prophase stages of dividing nuclei found during the later development of the germinating oöspore were observed

to contain the haploid number of chromosomes. The haploid number of chromosomes was found to be 14. However, the small size of the chromosomes made it difficult to be absolutely certain of the exact number. Meiosis, therefore, occurs during the first two divisions of the fusion nucleus.

During the divisions of the nuclei just described the central body was in most cases completely digested and the wall of the oögonium became thin. The germ tube arose at a point near the thin spot in the oögonial wall, at which spot the antheridium was attached to the oögonium. The tube penetrated through the wall of the oögonium at this spot. The cytoplasm and nuclei were observed to enter the germ tube. At the time of leaving the oöspore and entering into the germ tube, the nuclei were elongated and somewhat pointed.

LITERATURE CITED

1. Berlèse, A. N. Ueber die Befruchtung und Entwicklung der Oosphäre bei den Peronosporeen. Jahrb. Wiss. Bot. 31: 159-196. 1898.
2. Chaudhuri, H. *Sclerospora graminicola* on bajra (*Pennisetum typhoideum*). Phytopathology 22: 241-246. 1932.
3. Davis, B. M. The fertilization of *Albugo candida*. Bot. Gaz. 29: 297-311. 1900.
4. Evans, M. M. & Harrar, Geo. Germination of the oöspores of *Sclerospora graminicola* (Sacc.) Schroet. Phytopathology 20: 993-997. 1930.
5. Hiura, M. Studies on some downy mildews of agricultural plants. I. On *Sclerospora graminicola* (Sacc.) Schroet., the causal fungus of the downy mildew of Italian millet (the third preliminary note). (Japanese). Agric. and Hort. 4: 525-34. 1929.
6. —. A simple method for the germination of oöspores of *Sclerospora graminicola*. Science 72: 95. 1930.
7. —. Mycological and pathological studies on the downy mildew of Italian millet. Jour. Facul. Agr. Hokkaido Imp. Univ. Sapporo 36: 121-283. 1935.
8. Howe, Mary F. Oöspore and conidial response of species of *Sclerospora*. Unpublished thesis. Library, Iowa State College, Ames, Iowa, 1930.
9. Istvanff, C. Von. Ueber die Rolle der Zellkerne bei der Entwicklung der Pilze. Ber. Deutsch. Bot. Ges. 13: 452-467. 1895.
10. Krüger, F. Beitrag zur Kenntnis der Kernverhältnisse von *Albugo candida* und *Peronospora Ficariae*. Centralb. Bakt. Parasitenk. Infect. 27: 186-205. 1910.

11. Prillieux, E. Sur le *Peronospora Setariae*. Bull. Soc. Bot. Fr. 31: 397-398. 1884.
12. Rosenberg, O. O. Ueber die Befruchtung von *Plasmopara alpina* (Johans.). Bihang Sv. Vet. Akad. Handlingar 28: 1-20. 1903.
13. Ruhland, W. Die Befruchtung der *Albugo Lepigoni* und einiger Peronosporéen. Hedwigia 41: 179-180. 1902.
14. —. Studien über die Befruchtung der *Albugo Lepigoni* und einiger Peronosporéen. Jahrb. Wiss. Bot. 39: 135-166. 1904.
15. Stevens, F. L. The compound oosphere of *Albugo Bliti*. Bot. Gaz. 28: 149-176, 224-245. 1899.
16. —. Gametogenesis and fertilization in *Albugo*. Bot. Gaz. 32: 77-98, 157-169, 238-261. 1901.
17. —. Studies in the fertilization of Phycomycetes. Bot. Gaz. 34: 420-425. 1902.
18. Takasugi, H. & Akaishi, Y. On the germination of the oöspores of *Sclerospora graminicola* (Sacc.) Schröt. var. *Setaria-italicae*. (Japanese). Trav. Agric. and Hort. 7: 2277-2290. 1932.
19. Tasugi, H. Studies on the causal fungus of the downy mildew of the Italian millet. (Japanese). Ann. Phyto-path. Soc. Japan 2: 302-304. 1930.
20. Tsang, K. C. Recherches cytologiques sur la famille des Péronosporées; étude spéciale de la reproduction sexuelle. Le Botaniste 21: 1-93. 1929.
21. Wager, H. On the nuclei of *Peronospora parasitica*. Ann. Bot. 4: 127-146. 1889.
22. —. On the structure and reproduction of *Cystopus candidus*. Ann. Bot. 10: 295-342. 1896.
23. —. On the fertilization of *Peronospora parasitica*. Ann. Bot. 14: 263-279. 1900.
24. Weston, W. H. & Uppal, B. N. The basis for *Sclerospora Sorghi* as a species. Phytopathology 22: 573-594. 1932.

EXPLANATION OF FIGURES

Fig. 1. All drawings were made with the aid of a camera lucida. Magnifications are given for each drawing as reproduced. 1, $\times 1,350$, a drawing of a young oögonium which had almost completed expansion; 2, $\times 1,350$, a drawing of an oögonium with slightly thickened wall, to which an antheridium had become attached; 3, $\times 1,050$, a drawing of an oöspore in which zonation and the first division of the nuclei in the oögonium have started to take place; 4, $\times 1,350$, a drawing of an oögonium in which a mature oosphere has been produced; 5, $\times 1,050$, a drawing of an oögonium in which the conjugation tube has entered the oosphere and the male pronucleus has started to enter the conjugation tube; 6, $\times 1,350$, a drawing of a nearly mature oöspore in which the pronuclei were fusing.

Fig. 2. Drawings 1, 2, and 3 are reproduced at a magnification of 1,350. All other drawings are reproduced at a magnification of 2,300. 1-3, drawings of sections of germinating oöspores; 4, drawing of an antheridium in which the first division of the nuclei was taking place; 5, drawing of the

ruptured end of the conjugation tube from which the male pronucleus had entered the oöplasm; 6, a drawing of four dividing nuclei which were in the center of the oösphere; 7, a drawing of the first prophase in the oögonium; 8, a drawing of a late prophase of the first division of a nucleus in the oögonium; 9, a drawing showing the first metaphase of a nucleus in the oöplasm; 10, a drawing showing the first anaphase of a nucleus in the oöplasm; 11, a late anaphase of one of the later divisions taking place in the oögonium; 12, a fusion nucleus in prophase; 13, a fusion nucleus in diakinesis; 14, a drawing showing first anaphase of the fusion nucleus; 15, 16, drawings showing prophase nuclei of some of the later divisions which took place in the germinating oöspore; 17, an early telophase of a fusion nucleus; 18, a late telophase of a fusion nucleus.

PHOTOGRAPHS AND DESCRIPTIONS OF CUP-FUNGI—XXVI. THE GENUS DIPLOCARPA¹

FRED J. SEAVER

(WITH 1 FIGURE)

During the summer of 1936, Mrs. Cloyd B. Stifler of Chicago brought to the writer a considerable collection of discomycetes obtained in the Pocono Mountains in Pennsylvania and in Wychwood, Wisconsin. Most of these, while excellent specimens, were well known species. However, as often happens in such collections, one turned out to be of unusual interest. The species referred to had an olive-green hymenium suggesting a *Chlorosplenium* but possessed a hairy exterior which would exclude it from that genus. After a rather strenuous search the writer succeeded in determining this as *Peziza diplocarpa* described by Currey in England in 1864. The only specimen of this species in our collection was one obtained by Massee in England. So far as can be learned this species has not been reported from North America, and apparently only twice in the world.

In addition to the olive-green hymenium and brown exterior, the species has one very conspicuous character. The paraphyses are terminated by a large fusiform tip resembling a spearhead and looks very much like a fusiform spore. It is this character which suggested the specific name *diplocarpa*, which means two-fruited. Massee claims that the spearheads are conidia and has shown them in a germinating condition. While many discomycetes have lanceolate paraphyses the writer is familiar with only one other species (*Ionomidotis irregularis*) which has this spearhead tip, and that is not at all closely related to the present form.

In 1895 Massee established a new genus *Diplocarpa* based on this species. The characters are so unusual that the writer feels

¹ This paper is preliminary to a monograph of North American Cup-fungi (inoperculates), a companion volume to North American Cup-fungi (operculates), which was published by the author and issued in December, 1928.

he was justified in doing so, and since this species is practically unknown in America it seems fitting that it should be called to the attention of mycologists. The following is the diagnosis of the genus and the one species known.

DIPLOCARPA Massee, British Fungus-Fl. 4: 307. 1895.

Apothecia small at first closed, finally expanding and becoming shallow cup-shaped, attenuated below into a short stem-like base, densely clothed with short, septate, brown hairs giving the entire exterior a brown color; hymenium concave, olive-green; asci clavate, 8-spored; spores fusoid, containing several oil-drops and finally becoming septate; paraphyses filiform and surmounted with a fusiform conidium-like body.

DIPLOCARPA CURREYANA Massee, British Fungus-Fl. 4: 307. 1895.

Peziza diplocarpa Currey, Trans. Linn. Soc. 24: 153. 1864.

Lachnella diplocarpa Phill. British Discom. 232. 1893.

Apothecia gregarious or closely congested appearing sessile but actually short-stipitate at first closed then expanding and becoming shallow cup-shaped, reaching a diameter of 1–2 mm. externally dark brown, decidedly rough, tomentose, the roughening often vertically striated near the margin; hairs short septate, brown, with the tips often sharp-pointed; stem 1–1.5 mm. long, relatively thick about half as thick as long; hymenium concave, olive-green, becoming brownish with age; asci clavate, reaching a length of 70μ and a diameter of 7μ ; spores partially biseriata ellipsoid with 2 or 3 small oil-drops, finally becoming 1 or 2-septate about $3 \times 9\mu$; paraphyses slender, surmounted with fusoid, septate spore-like tips which reach a length of 28–32 μ and a diameter of 6–7 μ .

On much rotted wood, Wychwood, Wisconsin.

TYPE LOCALITY: England.

DISTRIBUTION: England and Wisconsin.

ILLUSTRATIONS: Currey, Trans. Linn. Soc. 24: pl. 25, f. 30, 32, 33; Phillips, British Discom. pl. 7, figure 43.

CONIDIA

Although Massee reports the paraphyses to be surmounted with conidia and shows them in a germinating condition, we have up to

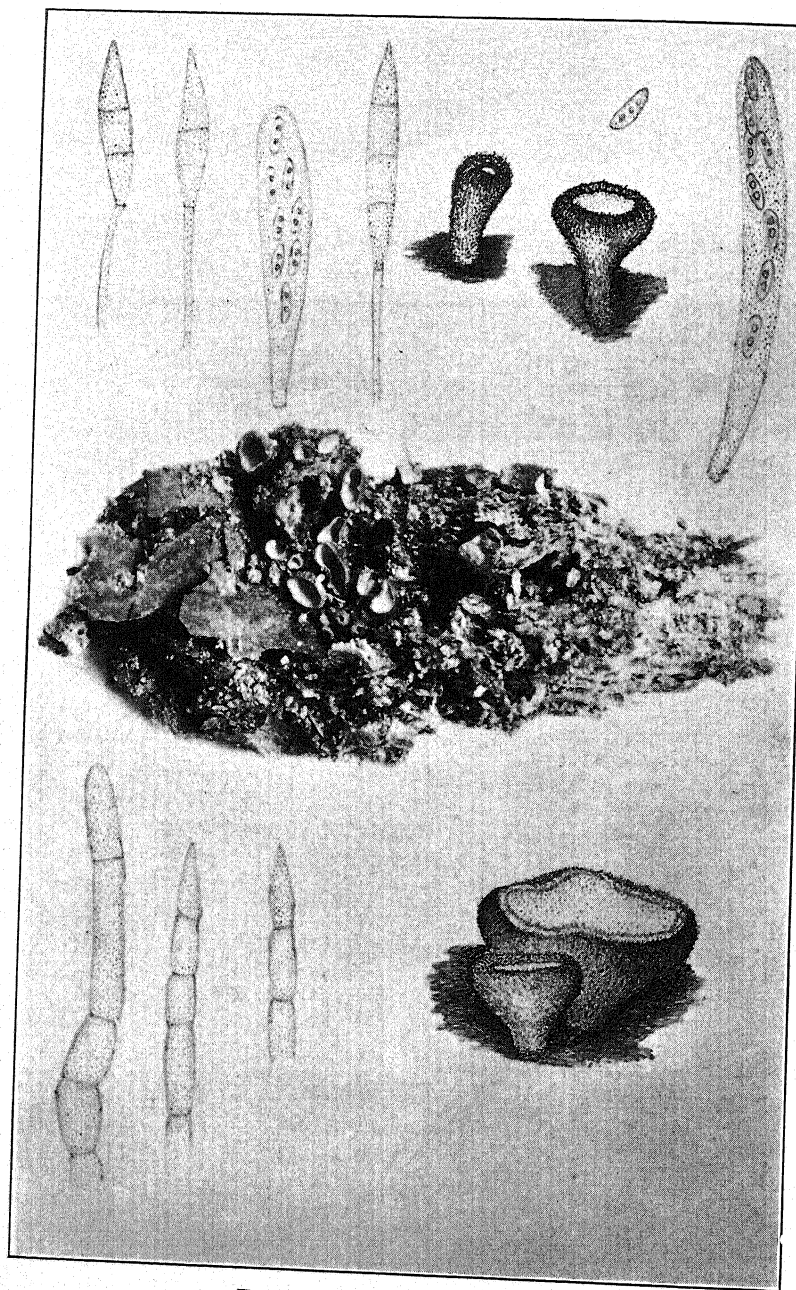


FIG. 1. *Diplocarpha Curreyana*.

date been unable to germinate those in our specimen. This does not prove anything since it is possible that they were killed in the process of drying. The collector has promised to make a search for more material, and in case it is found we will test this point further in culture.

Phillips (Brit. Discom. 338.) has called attention to the same character in *Encelia Bloxami* Phillips. He states "Fusiform, uni-septate, stylospores on slender filaments are abundantly intermixed with the asci and paraphyses, the summits rising a little above the surface of the hymenium." Drawings made from the type material by Massee show this species to be surprisingly similar to *Diplocarpa Curreyana*, except in the color of the hymenium which is brown instead of green. If the genus *Diplocarpa*, as established by Massee, is recognized Phillips' species should be included and would become ***Diplocarpa Bloxami*** (Phill.) comb. nov. Apparently Massee noted this similarity for a note on his drawings contains the following: "Is this the same as *Diplocarpa Curreyana*?" Phillips did not regard them as identical, and indeed they could not be, if the color of the hymenium as indicated by Phillips is correct. So far as the writer knows this species has not been found in America.

THE NEW YORK BOTANICAL GARDEN,
BRONX PARK, NEW YORK, N. Y.

EXPLANATION OF FIGURES

Center, photograph of group of plants $\times 4$; above, drawings of two apothecia, asci and spores and three paraphyses with their conidium-like apices; below, two apothecia much enlarged and hairs from outside of an apothecium.

A NEW SPECIES OF PHLYCTOCHYTRIUM ON HYDRODICTYON RETICULATUM

J. S. KARLING

(WITH 3 FIGURES)

In connection with previous studies on *Cladochytrium replicatum* Karling another chytrid was frequently encountered which is strikingly different in several respects from any other species of *Phlyctochytrium* heretofore described. It was first observed in abundance on dead cells of *Hydrodictyon reticulatum* in battery jar cultures during the winter of 1936, and since that time has been occasionally observed on dead *Oedogonium* filaments. In no instances so far has it been found parasitizing healthy, normal green cells. Extensive attempts have been made under laboratory conditions to infect healthy filaments of *Spirogyra crassca*, *Cladophara* sp., *Oedogonium* sp., and *Hydrodictyon reticulatum*, but so far the results have been negative. However, when such hosts were first killed by boiling, abundant infection occurred on *H. reticulatum*, and a few thalli were found on *Oedogonium* sp. The evidence from these preliminary tests thus indicate that this chytrid is primarily a saprophyte with a rather limited range of host tissues.

The outstanding characteristic of this species is the presence of from 3 to 30 greatly elongated, hyaline comparatively stiff but flexible, radiating, branched and continuous hairs or filaments on the surface of the extramatrixal zoösporangia. They begin to develop almost immediately after the zoöspores germinate, and may occasionally attain a length of 200 μ and branch several times. The intramatrixal sub-sporangial swelling or apophysis varies greatly in size and shape, and on its base is oriented an extensive rhizoidal system. The extramatrixal resting spores are hyaline, smooth, thick-walled and oval to spherical in shape. These characteristics together with its method of development places this species well within the limits of the genus *Phlycto-*

chytrium, as established by Schröter (1897), and at present there appears to be no question as to its identity and synonymy with other species which are characterized by setae or occur on *Hydrodictyon reticulatum*. This alga appears to be comparatively resistant to attack by chytrids, and up to the present time only two species have been reported on it, *Phlyctochytrium Hydrodictyi* by Braun (1855) and *Hyphochytrium Hydrodictyi* by Valkanov (1929). The former has been recorded three times since Braun discovered it, and the latter only once. The present species is quite different from either of these two, and there can be no doubt as to its distinction. In 1931 Valkanov described a chaetophorous species, *Rhizophidium* v. *Mindeni*, which Sparrow (1933) thinks is synonymous with Scherffel's (1925) *Chytridium chaetophilum*, on the oögonia of *Oedogonium* whose zoösporangia bear a superficial resemblance to those of our species, but the intramatrical system is quite different. It appears thus that we are dealing with a new and undescribed member of *Phlyctochytrium*, and with the view of emphasizing its outstanding characteristic I am proposing the specific name *chaetiferum* for this species.

***Phlyctochytrium chaetiferum* sp. nov.**

Zoösporangia gregarious, sessile extramatrical, predominantly pyriform and oval in shape, $12 \times 18 \mu$ to $30 \times 45 \mu$ in diameter; possessing from 3 to 30 elongated, flexible, branching hairs which are approximately 2μ in cross section at their point of insertion and sometimes attain a length of 200μ . Intramatrical apophysis or sub-sporangium spherical ($8-11 \mu$) irregular, elongated or spindle-shaped with one to several rhizoids oriented on its base or sides. Zoöspores spherical, 2.5 to 4μ in diameter with a single posteriorly attached cilium and a highly refractive globule in the center. Resting spores extramatrical, hyaline, smooth, thick-walled, oval and almost spherical, 9×10 to $14 \times 17 \mu$ in diameter. Apparently saprophytic on dead cells of *Hydrodictyon reticulatum* and *Oedogonium* sp., New York City.

GERMINATION OF THE ZOÖSPORES AND DEVELOPMENT OF THE INTRAMATRICAL THALLUS

The zoöspores of *P. chaetiferum* are spherical, hyaline, 2.5 to 4μ in diameter with a conspicuous clear refractive globule in the

center and a single posteriorly attached cilium which is approximately four times the diameter of the spore in length. Their general appearance and habit of swimming strikingly similar to that of other species of this genus, and nothing significantly different has so far been observed. They may frequently become amoeboid under conditions adverse to free swimming and drag their cilium behind, but when liberated they round up and dash off again. After a motile period which varies from 20 to 80 minutes they gradually come to rest, lose their cilium, and either degenerate or germinate. Under the laboratory conditions of this

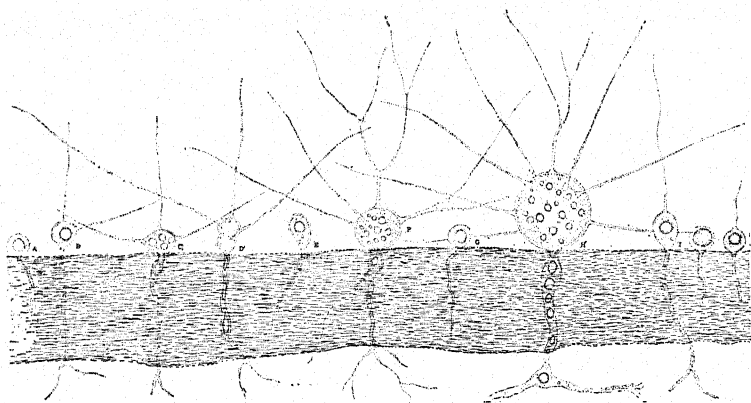


FIG. 1. Germination of the zoöspores and early developmental stages of *Phlyctochytrium chaetiferum* on a *Hydrodictyon* cell.

study a fairly high percentage of them have degenerated in the surrounding water. The remaining ones which come to rest on the host cell soon put forth a clearly visible germ tube which penetrates the cell wall as is shown in figures 1A, 1E, 1G and 1J. Figure 1 is a drawing of a portion of a *Hydrodictyon* cell on which were a large number of thalli in various stages of development and gives rather an exceptional view of this chytrid's relation to the host. The germ tube grows through the wall, and shortly after entering the lumen of the cell begins to branch, figure 1B. In some instances branching may occur within the host cell wall, as is suggested by figure 1F. These branches are the rudiments of the rhizoidal system, and as is shown in figures 1B and 1D the

chytrid very early lays down the anlage of an absorbing system within the host cell.

Very shortly after this branching has occurred the germ tube begins to swell and enlarge in a localized region just above the point of origin of the rhizoidal branches. This swelling increases in size and eventually becomes the intramatrix apophysis. The rhizoids become more and more oriented, particularly in the case of the spherical sub-sporangia, on its base, and one often gets the impression that the former was the first of the two to be developed. The apophysis usually lies immediately within the host cell, but

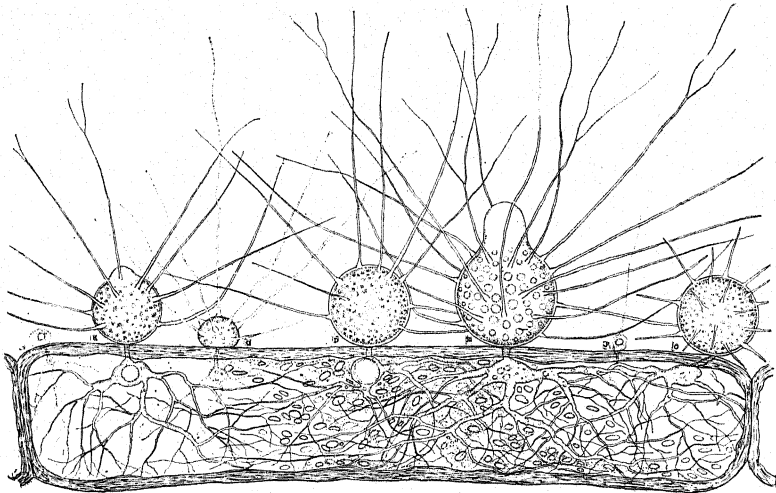


FIG. 2. *Phlyctochytrium chaetiferum* on a short *Oedogonium* cell.

in the case of old hibernating, winter nets it may often develop within the layers of the wall, as is shown in figures 1F and 1H. The mature apophysis varies considerably in size and shape, and it is accordingly difficult to give accurate and representative measurements. It may be almost spherical, 8 to 11 μ , figures 2D, 3E and 3F; irregular, figures 2B, 2E, and 2G; or reduced to an elongated and cylindrical tube, figures 3C, 3D and 3I; or somewhat spindle-shaped, figures 3G and 3H. In the majority of thalli so far observed the rhizoidal branches have been fairly closely oriented on the base of the apophysis, but this is by no means the general rule. In the case of the irregular ones shown in figures 2B, 2E,

and 2G they may originate at various places on the surface. The rhizoidal system is well developed and extensive in distribution as is shown in figure 2. At their point of insertion on the apophysis the branches may be as much as 5μ in diameter, but as they branch and ramify among the starch grains in the *Hydrodictyon* cells they diminish rapidly in thickness and eventually run out to fine points.

DEVELOPMENT OF THE ZOÖSPORANGIUM

Simultaneous with the branching of the penetration tube and the establishment of the anlage of the rhizoids and apophysis the hyaline setae appear on the surface of the extramatrixal zoöspore. In a few cases they have begun to develop before the germ tube has completely penetrated the host cell wall, figure 1K, while in others they have been considerably delayed. Usually a single or two protoplasmic hairs appears at the apex, figures 1I, 1K, 2F and 1B, but as the zoöspore begins to enlarge in size others are formed. They begin as minute projections or papillae on the surface, and then elongate rapidly without much additional increase in diameter, so that at maturity they are never more than 1.7 to 2.5μ in diameter at the point of insertion. They may branch several times, as is shown in figures 1F and 1H, and when fully developed may extend for a distance of 200μ in exceptional cases. As many as thirty hairs have been counted on a single zoösporangium. They are hyaline in color, continuous with the sporangia, filled with finely granular greyish protoplasm, and are comparatively stiff but readily flexible. This has been particularly evident in cultures of *Hydrodictyon* cells when rotifers were unusually abundant. Quite frequently the setae have been badly bent by such animals while feeding and crawling about, but when the pressure was released they sprang back into the original position. It is not uncommon, however, to find the bent and broken on mature and empty zoösporangia.

During germination of the zoöspore the refractive globule may remain in the spore body and increase in size or fragment into a number of smaller bodies. At least this often appears to be the case as is shown in figure 1C, although the successive stages have not been observed. Quite frequently similar globules may appear

in the penetration tube and incipient apophysis, figures 1D, 1F and 1H, and at maturity a very large refringent body of the same type may be found in the latter as is illustrated in figures 2B and 2D. As the zoöspore enlarges it may become somewhat flattened and dome-shaped on the surface of the host cell, figures 1C and 2C, but occasional double and constricted ones such as is shown in figure 1D may occur. At this stage the incipient zoösporangium usually appears well vacuolated, suggesting that growth in the early developmental stages is largely the result of imbibition of water. Figure 1F shows a more advanced zoösporangium which contains a number of refringent bodies of various sizes suspended in a rather dense and finely granular hyaloplasm. A later stage of development is shown in figure 1H in which the zoösporangium has almost attained mature size. The refractive globules are less in number and larger, which seems to be due to a coalescence of the smaller ones as the protoplasm matures. The setae extend in all directions except towards the host cell, while the intramatrical apophysis is reduced to scarcely more than an elongated tube. Following this stage a comparatively hyaline and clear region begins to protrude at the apex of the zoösporangium, figure 2B, which elongates considerably as is shown in figure 2E and eventually becomes the dehiscence papilla. As a result of this growth the zoösporangia usually becomes somewhat pyriform in shape, but it is not uncommon to find almost spherical ones also. The sporangium shown in figure 2E has reached mature size and is soon ready to undergo cleavage. The round refringent globules are approximately equal in size and except in the dehiscence papilla more or less evenly distributed throughout. Cleavage occurs in such a fashion that a single globule is included in each segment. Although the successive stages have not been followed it is without doubt progressive and predominantly centripetal in direction.

The mature zoösporangia of *P. chaetiferum* vary considerably in size and shape. The majority are somewhat pyriform, but almost spherical ones are not uncommon. The former vary from $12 \times 18 \mu$ to $30 \times 45 \mu$, while the latter range from 15 to 47μ in diameter.

Shortly after cleavage has been completed the dehiscence papilla opens and the zoöspores begin to escape. Only a limited

number of dehiscing zoösporangia have been observed and as yet it is difficult to draw definite conclusions as to the type method of exit and immediate behavior of the zoöspores. In a few instances the fully delimited zoöspores have escaped in a mass surrounded by a faint film or membrane and remained quiescent at the mouth of the zoösporangium, figure 3A, for a few minutes. Then as this film disintegrated they began to slowly move apart and swim

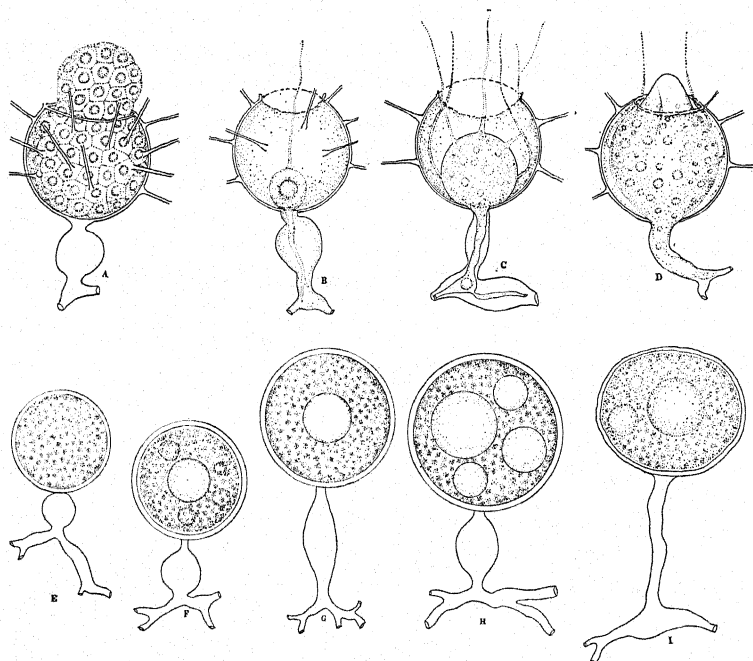


FIG. 3. Exit of the zoöspores, germination and development *in situ*, and the resting spores of *Phlyctochytrium chaetiferum*.

away. Whether the film is a surface tension membrane or a morphological one is difficult to determine in living material. Its refractive index is quite similar to that of the zoöspores, and may be readily overlooked. In other zoösporangia the zoöspores have escaped independently one by one without the presence of the membrane. It is not improbable in such cases that the membrane or film may break in the region of the dehiscence papilla as the zoösporangium opens, and the zoöspores are thus enabled to

emerge free and independent. The pressure of the cover glass and other mechanical factors may possibly influence the manner of exit also.

Quite often a number of zoöspores may fail to escape entirely, and frequently germination *in situ* occurs. The germ tubes may grow through the wall of the zoösporangium or down into the apophysis and rhizoids as is shown in figure 3B. Such thalli may continue to develop, and in two instances have been found to attain maturity. Figures 3C and 3D show such developmental stages. From such appearances one may readily get the impression that the zoösporangia of *P. chaetiferum* undergo proliferation, and quite recently Sparrow (1936) has interpreted similar thalli as such in *Rhizophidium simplex*. That this is not the case in the present species becomes evident when the successive developmental stages are followed.

RESTING SPORES

The resting spores of *P. chaetiferum* are hyaline, smooth, oval to almost spherical in shape, with walls approximately 2μ thick and usually one to several large refractive globules lying in the center as is shown in figures 3E and 3I. The spherical ones may vary from 10 to 17μ , and the oval ones $9 \times 10\mu$ to $14 \times 17\mu$ in diameter. They occur on the outside of the host cell in the same fashion as the zoösporangia, and usually develop in a culture after the latter have begun to disappear. So far no sexuality has been observed in their formation, nor have any germination stages been found.

SUMMARY

1. *Phlyctochytrium chaetiferum* has been found on dead cells and filaments of *Hydrodictyon reliculatum* and *Oedogonium* sp. which had been growing in battery jars in the laboratory. It is characterized by oval and somewhat pyriform extramatrical zoösporangia on which occur from 3 to 30 elongated, hyaline, continuous, branched, comparatively stiff but flexible hairs which may occasionally attain a length of 200μ . The intramatrical portion of the thallus consist of a globular, spindle-shaped, elongated, or irregular apophysis and a fairly extensive rhizoidal system oriented on its base or sides.

2. The zoöspores are hyaline, spherical, 2.5 to 4μ in diameter, with a large clear refractive globule in the center and a single posteriorly attached cilium which is approximately four times the diameter of the spore in length.

3. The resting spores are extramatrical, hyaline, oval to spherical in shape, with smooth thick walls and one or more large refringent globules in the center. So far no gametic fusion has been observed in relation to their development, nor have any germination stages been found.

BOTANY DEPARTMENT,
COLUMBIA UNIVERSITY

LITERATURE CITED

- Braun, A. 1855. Über *Chytridium*, eine Gattung Schmarotzergewächse Auf Algen und Infusorien. Abh. Akad. Wiss. Berlin 1855: 21-83.
- Scherffel, A. 1925. Zur Sexualität der Chytridineen. Arch. Protistk. 53: 1-58.
- Schröter, J. 1897. Chytridineae. E. & P. Nat.-Pfl. 11: 65-87.
- Sparrow, F. K. 1933. Inoperculate organisms collected in the vicinity of Ithaca, N. Y. with notes on other aquatic fungi. Mycologia 25: 513-535.
- . 1936. A contribution to our knowledge of the aquatic phycomycetes of Great Britain. Jour. Linn. Soc. London 50: 417-478.
- Valkanov, A. 1929. Protistenstudien. 5. *Hyphochytrium Hydrodictyi*—ein neuer Algenpilz. Arch. Protistk. 67: 122-127.
- . 1931. Beitrag zur Kenntniss der Süswasserphycomyceten Bulgariens. Arch. Protistk. 73: 361-366.

CROZIER FORMATION IN THE GYMNO-ASCACEAE: A PRELIMINARY NOTE¹

EDWARD D. DE LAMATER

(WITH 33 FIGURES)

INTRODUCTION

In April, 1935, some pellets of hair and feathers were found about a buzzard roost near Lock Raven, Maryland. These balls of material, apparently regurgitated by the buzzards, were placed in a moist chamber in the laboratory. About two weeks later a fluffy, yellow, mycelial growth was observed. The fruiting fungus was tentatively identified by Dr. C. L. Shear of the Bureau of Plant Industry as being *Arachniotus aureus* (Eidam) Schröter.

When cultures of a fungus regarded as the same species by Nannizzi were obtained from Baarn, Holland, and were compared with the organism from the buzzard castings, it became apparent that the two were quite distinct. A study of the original literature, as well as Saccardo's treatise of members of the family Gymnoascaceae, in the Sylloge Fungorum, shows clearly that the diagnoses are too inadequate to permit certain identification with them of fungi which may be found elsewhere. It seems certain that not only Nannizzi's species and the form from buzzard pellets, but also a dozen other species of the family now under cultivation in this laboratory, are actual bonafide members of the Gymnoascaceae. It is the writer's plan to make comparative studies of these during the next few years.

The writer is indebted to Dr. D. S. Johnson for facilities in carrying out his work, to Dr. J. N. Couch for his helpful suggestions, to Dr. C. L. Shear for his continued interest, and to Dr. D. H. Linder for transmission of valuable information.

¹ It would seem that the species discussed here is undoubtedly new, but no attempt will be made to name it until a comparative review of the group is presented.

HISTORY

Frederick Currey (1854), as I have learned from Dr. D. H. Linder, apparently described the first fungus belonging to the Gymnoascaceae. This fact seems to have been overlooked by most later workers.

Baranetsky (1872) described *Gymnoascus Reessii* in considerable detail, and founded the genus upon which the family is based. Eidam (1883 (a), 1883 (c), 1886) added appreciably to the numbers of known types in the group, as well as a good share of the total present day knowledge of their structure and sexuality. Brefeld (1891), Zukal (1890), Van Tieghem (1877), Matruchot and Dassonville (1899, 1901), Dangeard (1903-1907), and others have also contributed, but even so the available information is scant. Dale (1903) summarized the literature and studied morphologically and cytologically three members of the family, one very incompletely. Due partly to the small size of the fungi studied, and partly perhaps to the inadequate optical equipment available to her, Dale either failed to observe certain structures or failed to interpret them correctly. Her account, inadequate as it is, is unquestionably the most complete yet published for any of the organisms of this family. It is because of the possible reinterpretation of certain of Dale's figures from evidence obtained from the study of the development of this new (and interesting) form of *Arachniotus* here reported that this brief preliminary account is presented.

METHODS

Van Tieghem cells were used in the study of single spore inoculations, of spore germination, and of early hyphal stages. A Spencer micromanipulator was used for spore isolation. Observation for general characters, as well as for early sexual stages, were made on whole mounts of living material, and on acetocarmine preparations (Emmons, 1935). The latter were made permanent by Buck's method (1935).

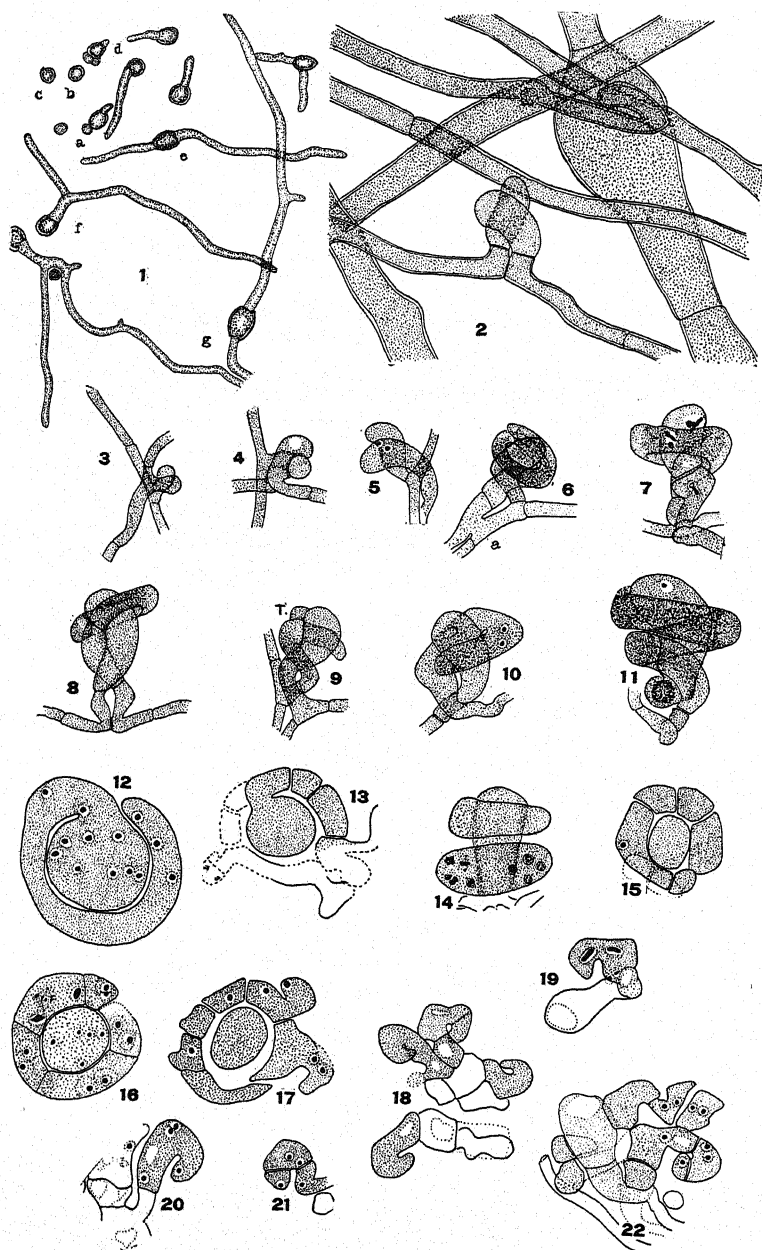
Most of the detailed study was done with paraffin sections of 4μ to 15μ in thickness. Schaudinn's and Gilson's fluids were the most satisfactory fixatives. Iron alum haematoxylin proved to be the most satisfactory stain. Sections stained with Haema-

toxylon (Haedenhein's) were destained in a saturated solution of picric acid in water, followed by dilute ammonium hydroxide to clear the picric acid and differentiate more clearly. (Ref. also Summers, 1935.) Other strains, such as Gram's fungus stain and Brazilin, have not been as useful. The Feulgen reaction has not as yet given consistent or satisfactory results, in this work.

THE ORGANISM

1. *Spore germination*: Spore germination occurs between 24 and 36 hours after the sowing of the spores on agar, the time depending upon the temperature. At first the spore swells to three or four times its original volume (FIG. 1 *a, b, c, d*); then, apparently anywhere on the spore surface, but usually at the narrower ends, a rupture occurs in the outer, heavy spore coat (FIG. 1 *c, d*) through which a small papilla or germ tube begins to protrude (FIG. 1 *d*). During succeeding hours the germ tube elongates (FIG. 1 *e, f*) and soon may or may not branch. Sometimes also two germ tubes may push out of the same spore at different places (FIG. 1 *e*); the second most commonly occurring on the side opposite the first. The spore coats have been observed to persist three or four days after germination clinging to the hypha as ragged, dark masses. Septations do not appear in the young hyphae until several hours after spore germination as a rule. The nuclear stages here have not as yet been followed.

2. *The vegetative mycelium*: The hyphae during vegetative growth vary considerably in thickness, both in aerial and subaerial mycelia. Ordinarily in actively growing, young cultures the hyphae are densely filled with cytoplasm, but in older stages in both layers of growth they become variously vacuolated. Hyphal fusions are of common occurrence in both kinds of mycelia. Figure 33 is a photomicrograph of such a fusion between two aerial hyphae. Figure 2 shows variations in hyphal thickness and also a characteristic swollen cell. Asexual spores are apparently formed only under very wet conditions, such as an agar plate flooded with water or in types of liquid media such as, potato-juice and sucrose. This is quite different from Nannizzi's fungus which forms abundant conidia under ordinary conditions.



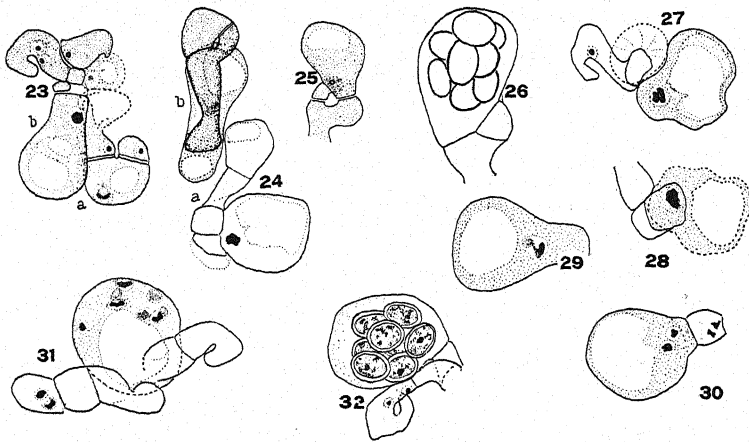
FIGS. 1-22.

The mycelia of *A. aureus* have been grown on potato-sucrose agar and on Sabouraud's glucose-peptone agar, as well as on several other media. On the first two media mentioned, the growth is much the same, except that on Sabouraud's radial furrows appear in the mycelium. At first, on both media, the growth is imbedded in the surface of the agar, but soon, the time depending on the wetness of the culture, a fluffy aerial mycelium appears. Vegetative cultures in which the aerial mycelium has arisen are pure white. The sexual phase is produced on both media, the time of initiation depending here apparently upon such factors as the light and water relations of the fungus. Such physiological factors need further investigation.

At the advent of the sexual phase a faint yellowish tint appears in the aerial mycelium, the occurrence of which seems to be a definite sign that the sexual phase has begun. Nannizzi notes the fact that sexuality is always accompanied by a similar color change in the European type of *A. aureus*. Furthermore it appears that the intensity of the color, which gradually deepens as maturity is reached, is a direct indication of the stage of sexual development reached by the fungus, and that light is evidently one of the primary factors affecting the initiation of the sexual organs; hence it may be found that here is a definite arbitrary index for a physiological study of the influence of light on sexuality. Examination of preparations made from any culture at a given time after the initiation of the color phase, shows that the sexual development of all male and female branches is, within limits, in about the same stage. Cultures grown in partial or total darkness fruit most readily. Wet cultures, as noted by Dale, fruit less rapidly.

3. *Origin of ascocarps*: The male and female branches may arise apparently from either the same or separate hyphae (FIG. 2, 3, 4, 5, 8). They arise much as described by Barenetsky for *Gymnoascus Reessii*, Eidam for *G. candidus*, Dale for both species. Nothing simulating what Eidam and Brefeld described for *G. Reessii* has ever been observed in this *Arachniotus aureus*. Eidam considered that a sexual branch coiled either about the parent hypha or about a neighboring hypha, and then gave rise to the sexual products, whereas Brefeld claimed a single sexual branch arose and subsequently gave rise to ascogenous hyphae and

asci without coiling either about another sexual branch or about the parent filament. The sexual branches appear as two small papillae or swollen knobs which lie closely, side by side, and are identical in appearance. These elongate, swell, and begin a very slight mutual coiling, one about the other (FIG. 4, 5) which never progresses very far. At this stage a wall separates each from its parent hypha and each branch is found to be uninucleate (FIG. 5). The fusion of the male and female cells may occur soon after this stage is reached or not until a much later time. Dale notes vari-



FIGS. 23-32.

ability in time of fusion and also variation in the dependent shape of the ascocarp. The writer regards the occurrence of fusion as a fairly well established fact, not only in this form but in *G. Reessii* and *G. candidus* as shown by Dale.

During further development the male branch elongates to a rather straight, club-like central cell, while the female branch (so designated because it gives rise to the ascogenous hyphae) continues to wind about the male in a coil of varying tightness. When fusion occurs early in the development, the male cell elongates beyond the point of fusion while the female also grows beyond this point coiling as it grows. If fusion occurs later, it is usually at or near the tips of the enlarged male and of the respectively coiled female cell. During these stages the number

of nuclei in both sexual branches increases. No evidence for the coiling about both sexual branches of a process derived from the female cell, as described by Dale, has ever been observed. About the time the branches have reached the stage shown in Figure 11, the coiling female begins to be cut up into cells which are usually very nearly isodiametric (FIG. 13, 15, 16). These are always binucleate (FIG. 16). It is believed that one of the two nuclei in each cell is derived from the original male and the other from the original female nucleus; although it will be difficult to establish this beyond doubt.

4. *Crozier formation*: Soon after the formation of the binucleate cells of the female branch, a process which is the fundament of a crozier begins to bulge out from each of them (FIG. 17). The two nuclei migrate into the characteristic hook and there undergo a simultaneous division (FIG. 19), followed by cell walls by which two non-sister nuclei are isolated in the bend of the hook, while one of the other pair is relegated to the base (pedicel) of the crozier and the other to the tip cell (FIG. 20, 21, 22).

5. *The ascus*: The binucleate cell at the bend of the crozier (cell *a*, FIG. 23) then begins to enlarge to form the ascus. At the initiation of this stage a vacuole appears, and, as the cell enlarges, the vacuole enlarges coincidently. A large vacuole is characteristic of the developing ascus, but it finally disappears about the time of spore formation.

Typically in crozier-forming Ascomycetes the uninucleate tip cell of the crozier is capable of fusion with the uninucleate basal (or pedicel) cell, thus reestablishing the binucleate condition (FIG. 24 *b*, 25, 26). When this occurs the newly established binucleate cell may then grow out to form a new crozier, and the above described process of ascus formation is repeated. Thus many asci may be formed from the relatively few original cells of the coiled female branch. Such a process, admirably diagrammed by Clausen, is believed to explain Dale's observations that the ascogenous hyphae in *G. Reessii* and *G. candidus* branch repeatedly forming dense clumps, each clump arising from one of the isodiametric cells of the coiled ascogonium. Dale evidently did not work out these later stages. No sterile cells have ever been observed to arise from the base of the ascocarp, consequently clusters of asci each de-

rived from a single sex act are merely nestled at random among the aerial hyphae with no other special protective sterile cells about them.

Dale's figures of early stages give fairly conclusive evidence that croziers are formed. Her figure 17 shows the segmentation of the female branch very clearly for *G. Reessii*. Figure 18 shows structures which are very like the croziers here drawn and described by the writer. In her consideration of *G. candidus* her figures 46 *a*, 46 *b*, 47 *a*, and 48 *b* show very clearly structures which, when compared with those described here (FIG. 17, 18, 19, 20, 21, 22), may well be considered to have the same significance. Her figure 48 *b* even suggests the formation of walls in the young crozier. The figures and descriptions given by Dangeard (1903-1907), Eidam (1883 (*a*), (*c*), 1886), Van Tieghem (1877), and others are not sufficiently detailed to draw any possible homologies from. It is of particular interest to find croziers in this species since it represents one of the lowest (possibly the lowest) of the Ascomycetes in which crozier formation has been reported.

Nuclear fusion has been demonstrated to occur in the young ascus of this *Arachniotus*. Figures 23 *a*, 24 *a*, 27, 28 show the establishment of this condition. The time of nuclear fusion may vary considerably, if the size and shape of the ascus can be considered as an indication of its maturity. Characteristically, by three subsequent divisions of this fusion nucleus eight spore nuclei are formed, about each of which a spore is delimited. The mode of spore delimitation seems to resemble that described by Harper (1900) in *Pyronema*.

The length of the pedicels of the asci, the presence or absence of which has been regarded as an important taxonomic character in these forms, is here so variable as to be of questionable taxonomic value.

TYPE OF SEXUALITY

In July and August, 1935, an attempt was made to determine whether this organism is hermaphrodite and sterile, as in *Pleurage anserina* and *Ascobolus magnificus*, or whether it might prove to be hermaphrodite and fertile as in *Pyronema confluens*. Curiosity as to the sexuality was aroused by the observations of hyphal fu-

sions between aerial hyphae bearing male and female branches (FIG. 6 a), and the early, preliminary observations which suggested that the male and female branches invariably arise from separate hyphae.

Some fifty single ascospore cultures each produced perithecia in which normal spored asci were to be found, thus indicating that the organism is either hermaphrodite and fertile or parthenogenetic. It may be said that cytological results so far



FIG. 33. Photomicrograph of hyphal fusion between two aerial hyphae.
Living material.

indicate, but do not prove, that this fungus is not parthenogenetic, but is a true case of hermaphroditism and self-fertility. The original uninucleate condition of each of the sex branches, the subsequent cellular fusion of the male and female branches, the binucleate condition of the cells of the ascogonium, and the activity of these nuclei in the subsequent stages of crozier formation seem to the writer to be very suggestive evidence for the above conclusion. The binucleate condition is very obvious in all material properly stained to show it. From the evidence so far available on this *Arachniotus aureus* from buzzard castings it would appear that the nuclear cycle and sexuality is like that of *Pyronema confluens* (Claussen, 1912).

DISCUSSION

The significance of the finding of croziers and simultaneous nuclear divisions in the formation of asci, become evident upon comparison with *Pyronema confluens* and other such supposedly higher ascomycetes, as well as on comparison with forms lower in the phylogenetic system, such as *Eremascus albus* (Eidam, 1883 (b)), in which the single ascus is derived directly from the ascogone itself. It is not surprising to find a true sexual process here, since such a process with a multitude of variations is known to occur in the yeasts, but it certainly is both surprising and of prime significance in the building of a phylogenetic system, to find a mechanism which has usually been considered as characteristic for "higher" ascomycetes. Croziers are known to occur occasionally in the fungi comprising the Aspergillaceae, as has been shown by Emmons (1935) for *Byssosclamyces fulva* Oliver and Smith. This was the only case among thirteen species studied. Croziers are also formed in *P. avellaneum*, as found by the writer (unpublished). In addition Emmons found three striking cases where the perithecia were distinctly gymnoascus-like, and others which were but little more complex. It would seem that this *Arachniotus* is probably the most primitive ascomycete in which croziers have been described.

SUMMARY

1. A new fungus regarded provisionally as *Arachniotus aureus* (Eidam) Schröter, was found on pellets apparently regurgitated by buzzards.
2. Upon comparison with Nannizzi's species by the same name, there was found to be no concurrence between the characters of the two fungi.
3. A preliminary study of the development showed:
 - (a) a true sexual process to occur, and
 - (b) crozier formation accompanied by conjugate nuclear division in the formation of asci.The stages are compared with figures drawn but not interpreted by Dale (1903).
4. Study of single ascospore cultures along with the cytological findings now available show that this species is probably monocious and self-fertile.

5. The significance and importance of the occurrence of croziers and monoeciousness in this and related organisms is emphasized.

6. The naming of this apparently new fungus is being left until a more comprehensive study of the family is presented.

DEPT. OF BOTANY,
JOHNS HOPKINS UNIV.

BIBLIOGRAPHY

- Baranetsky, J. 1872. Entwicklungsgeschichte des *Gymnoascus Reessii*. Bot. Zeit. 30: 145.
- Brefeld, O. 1891. Ascomyceten, II. Heft 10: 158.
- Buck, J. B. 1935. Permanent aceto-carmin preparations. Science, II. 81: 75.
- Claussen, P. 1912. Zur Entwicklungsgeschichte der Ascomyceten (*Pyronema confluens*). Zeits. Bot. 4: 1.
- Currey, F. 1854. On two new fungi. Quart. Jour. Mic. Sci. 2: 240.
- Dale, E. 1903. Observations on Gymnoascaceae. Ann. Bot. 17: 571.
- Dangeard, P. A. 1903-1907. Botaniste (9) and 10: 86.
- Eidam, E. 1880. Beiträge zur Kenntniss der Gymnoascaceen. Beitr. Biol. Pfl. 3: 267.
- . 1883 (b). Zur Kenntniss der Entwicklung bei den Ascomyceten. Beitr. Biol. Pfl. 3: 377.
- . 1883 (a). Ueber Entwicklungsgeschichte der Ascomyceten. Jahresb. Schles. Ges. 175.
- . 1886. Untersuchungen über die Familie der Gymnoascaceen. Ber. Bot. Sect. Schles. Ges. 164.
- Emmons, C. W. 1935. The ascocarps in species of *Penicillium*. Mycologia 27: 128.
- Matruchot, L. & Dassonville, C. 1899. Sur le *Ctenomyces serratus* Eidam Comparé aux Champignons des Teignes. Bull. Soc. Myc. Fr. 15: 305.
- . 1901. *Eidamella spinosa*, Dermatophyte Préduisant des Perithèces. Bull. Soc. Myc. Fr. 17: 123.
- Nannizzi, A. 1926. Ricerche sui Rapporti Morfologici e Biologici tra Gymnoascaceae e Dermatomiceti. Ann. Myc. 24: 85.
- . II. *Gymnoascus gypseum* (N. Sp.), *Sabouraudites* (*Achorion*) *Gypseum* (Bodin) Ota et Langeron. Ist. Bot. Univ. Siena. Reprint.
- Summers, F. M. 1935. The division and reorganization of Macronuclei, etc. Arch. Protistenk. 85: 176.
- Van Tieghem, O. 1877. Sur le Développement de quelques Ascomycetes. Bull. Soc. Bot. Fr. 24: 159.
- Zukal, H. 1890. Über einige neue Pilzformen und über das Verhältniss der Gymnoascaceen zu den übrigen Ascomyceten. Ber. Deuts. Bot. Ges. 8: 295.

EXPLANATION OF FIGURES

All drawings were made with the aid of a camera lucida.

Fig. 1. Germinating spores: *a, b, c, d*—early stages showing swelling of spores, rupture of spore coat, and sprouting of germ tube; *e, f, g, h*—slightly later stages showing branching and origin of two germ tubes from one spore. $\times 385$, all from living material. Fig. 2. Aerial hyphae showing variation in size, characteristic swollen cell, origin of male and female branches from one hypha. $\times 1335$, glycerine mount. Fig. 3. Young ascogonium and antheridium arising from different hyphae; living material. Fig. 4. Slightly older ascogonium and antheridium; living material. Fig. 5. Ascogonium and antheridium in uninucleate condition, with basal wall formed. $\times 1335$. Fig. 6. Ascogonium and antheridium from hyphae between which there is a hyphal fusion, *a*, but a few micra from the sexual branches; living material. Fig. 7. Later stage of ascocarp; chromatic masses in antheridium. Male cell, club shaped; female, coiling. $\times 1335$. Fig. 8. Stage as in 7. Male and female from same hypha. Acetocarmine mount. $\times 1335$. Fig. 9. Stage as in 7. Peculiar trichogyne like process, *t*. Living material. Fig. 10. Male and female branches showing cellular fusion. $\times 1335$. Fig. 11. Male and female branches prior to segmentation of ascogonium. $\times 1335$. Fig. 12 and 13. Cross-sections of male and female branches at point of cellular fusion. $\times 1335$. Fig. 14. Longitudinal optical section showing division figures in ascogonium. $\times 1335$. Fig. 15 and 16. Optical cross-section of ascocarps showing segmentation of female. Fig. 16 shows binucleate condition of female cells. $\times 1335$. Fig. 17. Optical cross-section; early stages in crozier formation. $\times 1335$. Fig. 18. Four croziers in slightly older stage. $\times 1335$. Fig. 19. Simultaneous division of two nuclei in crozier. $\times 1335$. Fig. 20. Crozier in which two non-sister nuclei segregated to bend, one in tip and one in base of crozier, prior to wall formation. $\times 1335$. Fig. 21. Production of young binucleate ascus by formation of cross-walls. $\times 1335$. Fig. 22. Longitudinal section through ascocarp showing crozier as in 21. $\times 1335$. Fig. 23. Enlargement of young ascus, *a*, in which characteristic vacuole is forming. Nuclei possibly fusing. *b*, Older stage of ascus development. Large fusion nucleus present. $\times 1335$. Fig. 24–26. Showing fusion of tip cell of crozier with basal cell. Fig. 26, late stage. $\times 1335$. Fig. 27 and 28. Older uninucleate asci. Nucleus in Fig. 27 probably fusing. $\times 1335$. Fig. 29. Possible first division stage in ascus. $\times 1335$. Fig. 30. Binucleate condition in older ascus. Note binucleate condition of Basal cell. $\times 1335$. Fig. 31. Eight-nucleate condition of ascus prior to spore formation. Nuclei at different levels. $\times 1335$. Fig. 32. Aspect of ascus and spores stained with iron alum haematoxylin. $\times 1335$.

UNDESCRIBED SPECIES OF CERCOSPORELLA AND CERCOSPORA ON CERTAIN GRASSES IN OREGON AND WASHINGTON¹

RODERICK SPRAGUE²

(WITH 3 FIGURES)

During investigations on the host range of *Cercosporella herpotrichoides* Fron on cereals and other grasses (5), three apparently undescribed species of *Cercospora*-like fungi were found, one each on *Holcus lanatus* L. and *Bromus rigidus* Roth in the field, and a third on *Melica subulata* (Griseb.) Scribn. on an herbarium specimen of this grass collected by the late D. C. Ingram. The writer uses the term "*Cercospora*-like" on account of the partially accepted practice of including *Cercosporella* and *Cercosporina* in the genus *Cercospora*. While this grouping appears to be the logical one, it is not universally accepted. For this reason, the genus name, *Cercosporella*, will be retained in this paper but the alternate combinations also will be given.

In the Pacific Northwest there are no described species of *Cercospora*-like fungi listed on grasses or cultivated cereals except *Cercosporella herpotrichoides*, *Cercospora fusimaculans* Atk. and *Scolecotrichum graminis* Fuckel which latter Horsfall has transferred to the genus *Cercospora*, making the combination *Cercospora graminis* (Fuckel) Horsfall (3).

Cercosporella Holci sp. nov.³

Maculis luteis, vel pallide brunneis, ellipticis, dein confluentibus; margine luteo v. pallide brunneo; myceliis hyalinis v. chlorinis, 0.5–1.2 μ diam., septatis,

¹ Coöperative investigations by the Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, and the Oregon and Washington Agricultural Experiment Stations. Published as Technical Paper No. 251 of the Oregon Agricultural Experiment Station.

² Associate pathologist, Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture.

³ In the genus *Cercospora* the combination would be *Cercospora Holci* sp. nov.

ramosis, myceliis stromaticis sparsis; conidiophoris carentibus v. brevibus, $5-20 \times 1.2-2.5 \mu$, hyalinis v. chlorinis; conidiis hyalinis, rectis v. curvulis, raro recurvulis, obclavato-filiformibus, pluriseptatis (1-9), $40-105 \times 1.5-3.0 \mu$.

Hab. in foliis *Holci lanati* L.

Spots tan, yellow bordered to darker buff or tawny, elliptical or extensive scald-like lesions on any or all leaves of a plant in mid to late winter and early spring. Mycelia hyaline or faintly chlorine tinted, intracellular and intercellular, 0.5 to 1.2μ in diameter,

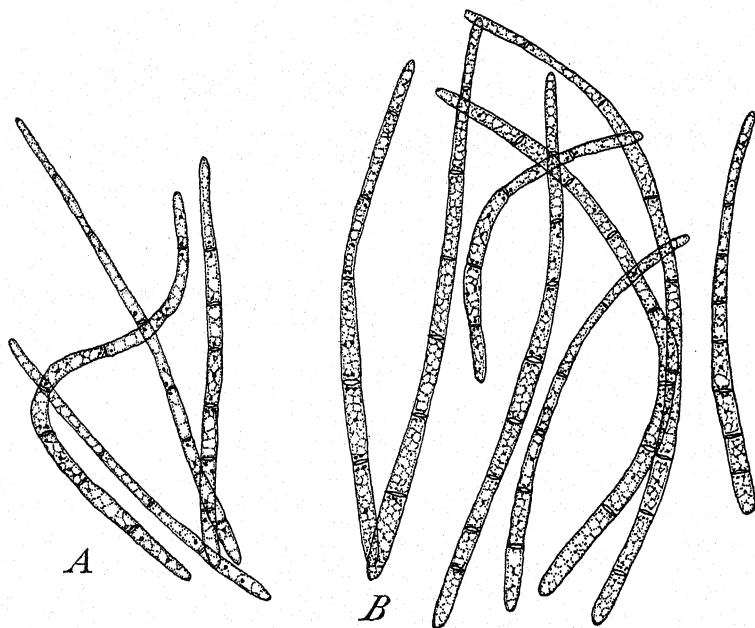


FIG. 1. *A*, conidia of *Cercospora Holci* from the type collection, Oregon specimen No. 10202, $\times 1000$; *B*, conidia of *Cercospora Holci* from Oregon specimen No. 10227, $\times 1000$; the conidia from this specimen average slightly larger than those from the type collection No. 10202.

septate, branched; stromatic mycelia loose or nearly absent except subhyaline aggregates in the stomatal cavities and adjacent internal and external leaf parts. Conidiophores frequently but little differentiated from the fruiting stroma, or short, erect, simple or once branched $5-20 \times 1.2-2.5 \mu$, hyaline or faintly chlorine, most common near or in the stomata, sterile hyphae and/or developing spores $10-31 \times 1.5-2 \mu$, mingled with the fruiting hyphae. Conidia hyaline, straight to slightly curved, rarely double reflexed, attached at the larger elliptically rounded base, slender obclavate-

filiform, 1-9 septate, distal end tapering, rounded, contents homogeneous with small globules in the larger cells, $40-105 \times 1.5-3.0 \mu$ (FIG. 1, A and B).

On leaves of *Holcus lanatus* L. in Oregon and Washington.

The following numbered specimens are deposited in the Mycological Herbarium of the Oregon State College:

Collected in Oregon: Alsea Mts. (Benton Co.), 10,202 (Type); Alsea Valley (Lincoln Co.), 10,203 and 10,204; Near Troutdale (Clackamas Co.), 10,227; Lobster Valley (Lincoln Co.), 10,274; East Corvallis (Linn Co.), 10,358; Fall Creek (Lincoln Co.), 10,404; Peavey Arboretum (Benton Co.), 10,410.

Collected in Washington: Bingen (Klickitat Co.), 8089 and 8135.

In severe cases of infection, *Cercospora Holci* caused a reaction similar to a scalding or snow injury. The fungus evidently is favored by cold weather, the same as *C. herpotrichoides* (6). *Cercospora Holci* differs, however, from *C. herpotrichoides* in a number of important respects. While *C. herpotrichoides* confines its attack to the culm at the soil line, *C. Holci* causes a leaf spot and rot. The development of dark stromatic (*Cercospora*-like) mycelia in *C. herpotrichoides* is considerable (6) while that in *C. Holci* is usually slight and is subhyaline in color (true *Cercospora*).

Morphologically, the conidia of *Cercospora herpotrichoides* are distinctly broader and more obclavate than those of *C. Holci*. In pure culture on potato dextrose agar the former differs from *C. Holci* in producing a more compact, mounded type of growth which is of a darker gray color than that of *C. Holci*.

From the fact that *Cercospora Holci* is not found on any grasses growing in close association with *Holcus lanatus* it is believed that the local host range of this fungus is limited. If it is a recent transfer from a non-graminicolous host its range on other hosts would not be determinable under present conditions inasmuch as there are over 1,000 species of *Cercospora*-like fungi described. Notwithstanding the fact that there are these hundreds of species described, the number on grasses is relatively small, and most of the ones described on this extensive family are robust species entirely distinct from any of the new species found in

Oregon and Washington on grasses. After comparing with all descriptions of grass inhabiting *Cercospora*-like species and with available exsiccati the writer is convinced that *C. Holci* is distinct. W. W. Diehl, Bureau of Plant Industry, U. S. Department of Agriculture, kindly examined the Mycological Collections of the Bureau of Plant Industry at Washington, D. C., and determined that this fungus apparently has no counterpart in that herbarium. Dr. Diehl was of the opinion that the fungus was undescribed.

***Cercospora subulata* sp. nov.⁴**

Maculis effusis, confluentibus, praelongis, sordide stramineis vel olivaceo-luteis, dein isabellinis; margine fusco, v. luteo-brunneo; myceliis vegetis hyalinis v. chlorinis, septatis, $1-2\ \mu$ diam.; myceliis stromaticis olivaceis dein obscuro-nigris; conidiophoris hyalinis v. chlorinis, brevibus, $5-20 \times 1.5-2\ \mu$; conidiis numerosis, hyalinis, subulato-filiformibus, extremo flagelliformibus, raro rectis, fere curvulis, raro recurvulis; conidiis $1-2$ septatis, $20-35 \times 2.5-4.3\ \mu$, fere $28-33 \times 2.8-3.5\ \mu$.

Hab. in foliis, et vaginis *Melicae subulatae* (Griseb.) Scribn.

Lesions extensive, elongate, sometimes diffused as a scald over large portions of the leaves, sordid dull straw color to olive buff and isabelline bordered by darker tones of umber to buffy brown. Vegetative mycelia hyaline to strongly chlorine, septate, branched, $1-2\ \mu$ in diameter, stromatic mycelia olivaceous to dull black, aggregated at or near the leaf surface from which are produced short, hyaline to strongly chlorine conidiophores, $5-20 \times 1.5-2\ \mu$. Conidia hyaline, produced in large numbers, borne blunt, broad base down, subulate-filiform tapering to a whip-like distal portion which is sometimes straight, usually curved or flexuous, rarely reflexed. Conidia sometimes 1-septate, usually 2-septate with basal septum at broadest portion of subulate base, sometimes slightly constricted at second septum from base, which usually is at basal end of whip-like distal portion. In old material conidia frequently break at this second septum. Conidia $20-35 \times 2.5-4.3\ \mu$, mostly $28-33 \times 2.8-3.5\ \mu$ (FIG. 2, A).

On leaves and sheaths of *Melica subulata* (Griseb.) Scribn., Main Divide Trail in Ochoco National Forest, Oregon. Aug. 21, 1916. D. C. Ingram (Ingram B. 606 Oregon State Phanerogamic Collection Sheets No. 23,260 and 23261; Oregon Mycological Collections 10,669).

⁴ In the genus *Cercospora* the combination would be *Cercospora subulata* sp. nov.

The sperm-like conidium of *Cercosporella subulata* is different from the usual conception of a *Cercosporella* spore. The whip-like distal portion of *C. subulata*, however, is definitely a part of the cytoplasmic structure of the spore and is not a vacuolated or empty appendage such as occurs in *Pseudodiscosia* Host. and Laub., in the apiculated *Dactylella tylopaga* Drechs. (1) or in *Mastigospo-*

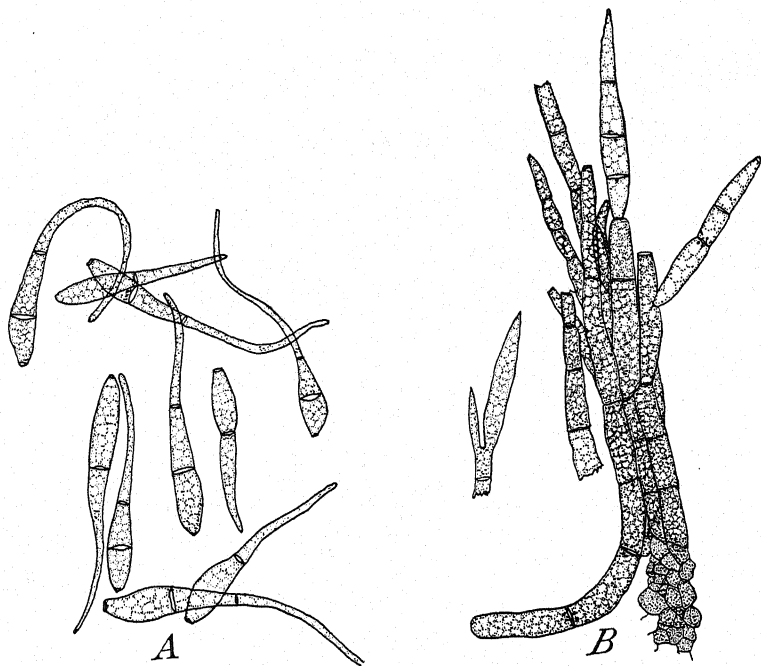


FIG. 2. A, conidia of *Cercosporella subulata* from type material, $\times 1000$; B, conidiophores and conidia of *Cercospora Bromi* from type material, $\times 1000$.

rium Riess. Solheim (4) illustrates species of *Cercospora*, which approach the sperm-like shape of *C. subulata*.

Cercosporella subulata, *C. herpotrichoides* and the species described later in this paper are the only *Cercospora*-like species known on the tribe Festuceae of the Gramineae. There are no comparable species on the Gramineae, and on this differential basis *C. subulata* is a distinct species.

Cercospora Bromi sp. nov.⁵

Maculis griseis dein sordidis, elongato-striatis, margine fusco v. brunneo; myceliis vegetis variabilibus, hyalinis v. subhyalinis v. fuliginosis; myceliis stromaticis olivaceis dein obscuro-nigris; conidiophoris carentibus v. in longitudine variabilibus, simplicibus v. furcatis, singulis v. fasciculatis, fuliginosis v. chlorinis; conidiis hyalinis, acrogenis et subacrogenis, obovato-fusiformibus, rectis v. curvulis, 1-4 septatis, $15-45 \times 2.5-5 \mu$ ($25-43 \times 3-4.5 \mu$); conidiis secundariis $3-15 \times 0.8-2 \mu$, aseptatis.

Hab. in foliis, culmis, vaginis et glumis vivis *Bromi rigidi* Roth.

Spots gray to sordid, elliptical or striate with broader margins dark brown to umber. Vegetative mycelia variable, hyaline to subhyaline to fuliginous, hyphal cells variable in size and shape, rectangular to angular, becoming subspherical or bulbous, stroma dark olive to dull black filling epidermal cells with polygonal and irregular cells and spreading from there to outer surface of the host through stomata. Conidiophores variable in length, sometimes obscure, simple or once branched, single or fascicled to form coremium-like aggregates, fuliginous to chlorine colored (FIG. 2, B). Conidia hyaline, borne singly or in pairs, acrogenously or subacrogenously, obovate-fusiform, slightly curved, 1-4 septate, slightly constricted at septa, base blunt with prominent scar or hilum, $15-45 \times 2.5-5 \mu$ (mostly $25-43 \times 3-4.5 \mu$; secondary conidia produced singly on from 25 to 80 per cent of the conidia, usually from the second or less commonly from the first basal cell, deflected at 45 degree usually toward the leaf base, slender fusiform, $3-15 \times 0.8-2 \mu$ (mostly $10-12 \times 1.5-1.8 \mu$), non-septate, semi-deciduous (FIG. 3).

On leaves, sheaths, culms and glumes of *Bromus rigidus* Roth, near Tumwater, Wasco Co., Ore. (10,405 (Type)) and at Corvallis, Ore. (10,751).

This fungus was collected in the semi-arid sandy reaches along the Columbia River in eastern Wasco County, Ore., in March 1935, and in a vacant lot in the semi-humid region at Corvallis, Ore., in May 1936. In the abundant material at Corvallis the disease was characterized by the gray, striate lesions which produced an anthracnose-like superficial lesion on the various green parts of the plants. While very superficial on the silicified culm parts, the fungus apparently caused considerable stunting, particularly where the attack had reached the heads. The disease is of no

⁵ In the genus *Cercosporina* the combination would be *Cercosporina Bromi* sp. nov.

economic importance; in fact, this grass, which is called ripgut, is the least desirable of the cheat grasses, which generally are troublesome weeds in the Pacific Northwest.

The secondary conidia of *Cercospora Bromi* are somewhat different from those on any other fungus seen by the writer. Because they are semi-deciduous, they are considered secondary co-

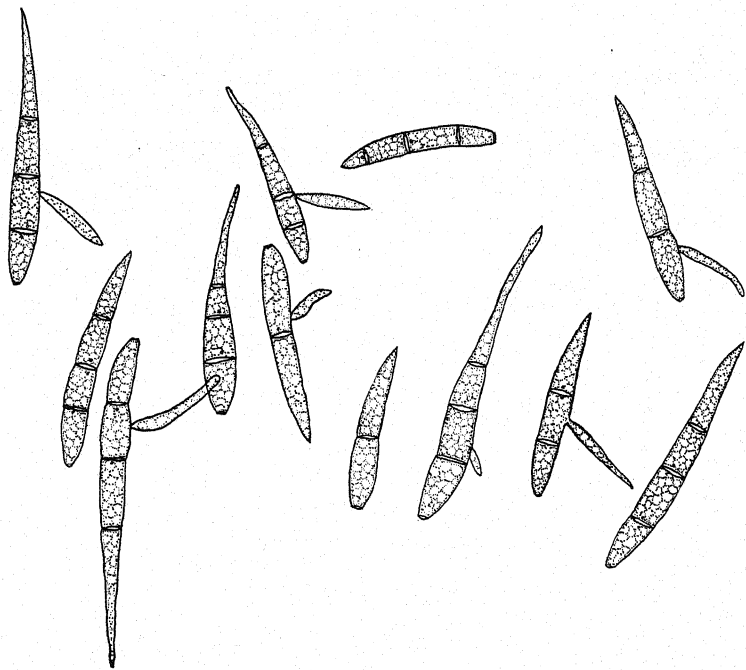


FIG. 3. Conidia of *Cercospora Bromi* from type material, $\times 1000$.

nidia rather than germ tubes, although the distinction between these in other *Cercospora*-like fungi is sometimes not great. For example, Foëx and Rosella (2) mention secondary conidia in *Cercospora herpotrichoides* and Sprague and Fellows (6) have seen these and illustrated them but make the notation that they almost immediately germinate again. In *Cercospora Bromi*, germination is apparently definitely arrested. These secondary conidia are not cilia such as occur in *Pseudodiscosia Avenae* Sprague and Johnson (7). The chlorinous nature of the coloring and the type of appendage removes it from *Mastigosporium* Riess. While it is rec-

ognized that the regularity of the formation of the conidia is remarkable, it seems clear that the fungus belongs in the genus *Cercospora*.

LITERATURE CITED

1. Drechsler, Charles. A new mucedinaceous fungus capturing and consuming *Amoeba verrucosa*. *Mycologia* 27: 216-223. 1935.
2. Foëx, E. & Rosella, E. Sur les diverses formes du piétin. *Rev. Path. Vég. Ent. Agric.* 17: 41-51. 1930.
3. Horsfall, James G. A study of meadow-crop diseases in New York. New York (Cornell) Agr. Exp. Sta. Mem. 130: 1-139. 1930.
4. Solheim, W. G. Morphological studies of the genus *Cercospora*. III. (Univ.) *Biol. Monog.* 12¹: 1-84. 1929.
5. Sprague, R. Relative susceptibility of certain species of Gramineae to *Cercospora herpotrichoides* Fron. *Jour. Agr. Res.* (In press).
6. — & Fellows, H. *Cercospora* foot rot of winter cereals. U. S. Dept. Agric. Tech. Bull. 428: 1-24. 1934.
7. — & Johnson, A. G. A new *Pseudodiscosia*. *Mycologia* 28: 181-185. 1936.

A NEW SPECIES OF CANDELOSPORA CAUSING DECAY OF CITRUS FRUITS¹

H. S. FAWCETT AND L. J. KLOTZ

(WITH 6 FIGURES)

In January, 1932, at Citra, Florida, a new fungus was isolated from a decayed portion of an orange fruit. A firm type of decay had started on one side. The rotted region was slightly sunken, with a definite margin, brown on the exterior, and brownish through the albedo and for a short distance inward on the divisions between the segments.

Inoculations made in injuries in the rind of oranges, lemons, and grapefruit resulted in decay similar to that from which the fungus was isolated. The fungus was again isolated from the decayed portion of these inoculated fruits.

TYPE OF DECAY PRODUCED BY INOCULATIONS WITH CANDELOSPORA

Although the rate of decay varied with the temperature, the type of decay was similar at most of the temperatures within a certain range. The following is a description of the decay as it appeared at 20° C. and a relative humidity of about 85 per cent. On mature Valencia orange fruits taken directly from the tree and inoculated in September, the decay spots, after 4 weeks (FIG. 1), had definite margins, were firm, and were cinnamon brown to Prout's brown in color.² On cutting, the entire thickness of the rind was found discolored and part of the pulp affected but not yet discolored. At temperatures a few degrees higher the divisions of the segments and core showed light-colored mycelium.

¹ Paper No. 352, University of California Citrus Experiment Station and Graduate School of Tropical Agriculture, Riverside, California.

² Color nomenclature throughout this article from: Ridgway, Robert. Color standards and color nomenclature. 43 p. 53 colored plates. Published by the author, Washington, D. C. 1912.

At 20° C. inoculations on light green lemons direct from the tree developed decay which, externally, was mars brown in color. The rind, pulp divisions, and core were dark brown to black (FIG. 2). The pulp, exclusive of divisions, was usually not discolored. At higher temperatures the external diseased areas were smaller, but

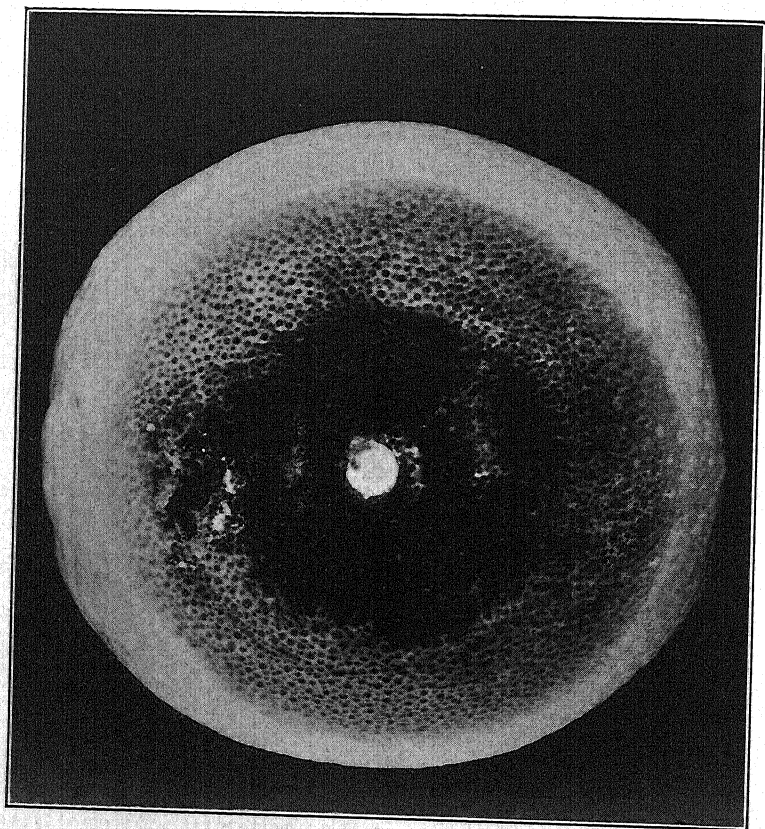


FIG. 1. Decay in Valencia orange produced by *Candelospora Citri* in a 4 weeks' incubation at 20° C.

on cutting, the discoloration was found extending around the inside of the rind on the divisions and throughout the core. This internal discoloration (FIG. 2) was similar in extent but darker and firmer than typical center rot of lemons due to *Alternaria Citri*.

Microscopic examinations in both oranges and lemons showed hyphae of the fungus to be abundant in the stalks of the juice sacs but not present on or in the juice sacs themselves. This was possibly due to the inability of the fungus to grow at the H-ion concentration of the lemon and orange juice.

EFFECT OF VARIOUS TEMPERATURES ON GROWTH AND PATHOGENICITY OF THE FUNGUS³

Transfers with mycelial disks 4 mm. in diameter were placed on glucose-potato agar in the center of petri dishes. Five dishes



FIG. 2. Internal decay of lemon and Valencia orange caused by *Candelospora Citri*.

were placed in each of seven constant-temperature cabinets. The temperature of any one cabinet varied less than $\frac{1}{2}^{\circ}$ C. from the mean. The rate of invasion of citrus fruit by the fungus at the several temperatures was also studied. Orange and lemon fruits were inoculated by placing a drop of spore-mycelium suspension in each of 2 uniform wounds made on opposite sides of the rind

³The authors wish to acknowledge the assistance of L. L. Huillier in carrying out these experiments.

at the equator. The wounds were made by removing from the rind with a cork borer a disk 4 mm. in diameter and 2 mm. deep. One of the two inoculations was covered with a small piece of adhesive tape. The fruits were then wrapped in packing tissue and placed in paper bags.

One set of inoculations was made on August 28, 1935, and the other on November 9, 1935. Since the results of these two sets appeared to fit fairly well into one series, they are combined here into one table (table 1). Two measurements of the diameter of

TABLE 1
DIAMETER, IN MILLIMETERS, OF MYCELIAL DISK AND DECAY LESIONS DUE
TO INOCULATIONS WITH *Candelospora Citri*

| Temperature, ° C. | Mycelial disk in 6 days | Decay on yellow lemons in 21 days | Decay on green lemons in 22 days | Decay on mature Valencias in 22 days | Decay on green Valencias in 22 days |
|----------------------|-------------------------------|-----------------------------------------|-------------------------------------------|-----------------------------------------------|----------------------------------------------|
| 7.7 * | 0.0 | —† | 0.0 | 0.0 | — |
| 11.8 | 21.9 | 24.1 | 12.7 | 21.5 | 13.2 |
| 14.0 * | 24.0 | — | 17.0 | 21.5 | — |
| 17.3 | 42.2 | 28.4 | 11.8 | 26.1 | 24.7 |
| 19.8 * | 45.0 | — | 12.0 | 36.2 | — |
| 21.5 | 52.1 | 40.6 | 9.1 | 35.3 | 31.7 |
| 24.0 * | 53.0 | — | 9.4 | 41.6 | — |
| 25.5 | 58.2 | 45.0 | 8.6 | 36.3 | 10.4 |
| 27.5 * | 37.0 | — | 6.0 | 29.5 | — |
| 29.3 | 41.1 | 9.9 | 6.2 | 21.9 | 9.3 |
| 30.4 * | 15.2 | — | 6.2 | 7.0 | — |
| 35.0 * | 0.0 | — | 0.0 | 0.0 | — |

* Average temperatures used to obtain data during the period beginning August 28, 1935. The remaining temperatures were used in the experiment begun November 9, 1935.

† — indicates no test made at this temperature.

each mycelial growth were made and the average taken. The average of the readings of the 5 petri-dish cultures, which includes the initial 4-mm. disk, are recorded in the table for the first 6 days. Similarly the diameters of the fruit lesions were also measured and the averages for the 22-day period of incubation recorded. This interval of 22 days was chosen in order to obtain a common time interval for combining the 2 tests. The temperature relation as a whole was about the same for all time intervals recorded.

Table 1 indicates that the optimum temperature for growth on glucose-potato agar is near 25.0° C., that the minimum is above

7.7° C. but below 11.8° C., and that the maximum is above 30.4° C. but below 35.0° C. A similar relation is indicated for rate of decay on mature lemon and orange fruits. For green fruits, however, the rate of decay is not only lower at all temperatures tested, but there is evidence that the optimum temperature for the development of lesions is much lower than that for mature fruits. The largest surface lesions on green lemons developed at 11.8° and 14.0° C., and those on green Valencias at 17.3° and 21.5° C.

THE CAUSAL FUNGUS

A study of this fungus shows that it belongs to the genus *Candelospora* erected by Hawley (2). As far as known no other species of this genus has been described. This was described as *Candelospora ilicicola* Hawley on leaves of *Ilicis aquifolium* in Ireland. The genus, according to Hawley, "differs from *Mucrosporium* in its penicillate branching and in its conidia produced singly at the tips of the branchlets."¹

The *Candelospora* species on citrus differs from *C. ilicicola* Hawley in having smaller spores, in having fawn to vinaceous fawn-colored mycelium instead of white tufts, and in the lack of mucus in the heads. The citrus species has in some cultures a characteristic torch- or beacon-like hypha 240 to 275 μ in length which terminates in a swollen end. The end is usually elliptical in shape but may have several other forms (FIG. 3). Usually one conidiophore, occasionally more, develops on this structure at a point 60 to 90 μ from the union with the mycelium. Rarely an aerial torch-like hypha is found that bears no fruiting body. Oc-

¹ The genus *Cylindrocladium* first described by Morgan (4) in 1892 resembles the genus *Candelospora*. However, the figure of *Cylindrocladium scoparium* by Morgan shows 2-celled (1-septate) spores and a fruiting structure exclusive of spores having a system of branches numbering 6 divisions in some instances. *Candelospora Citri* usually has 4 such divisions. The monopodial club-like or beacon-like hyphae, which we have seen in some cultures of *Candelospora*, were not described or figured by Morgan for *Cylindrocladium*.

Both Massey (3) and Anderson (1) found that *Cylindrocladium* spp. have the club-like hyphae and their figures and descriptions otherwise closely resemble *Candelospora Citri*. The conidium of *Cylindrocladium* spp., however, has but two cells.

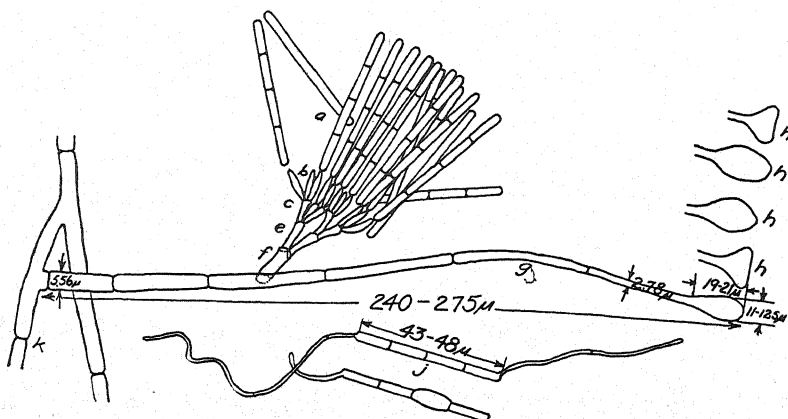


FIG. 3. Tracing of photomicrograph of *Candelospora Citri* showing morphology of fructification: *a*, conidia; *b*, sterigmata; *c*, rami; *e*, metulae; *f*, conidiophore; *g*, torch-like structure with swollen end cell (*h*); *j*, germinating conidia.

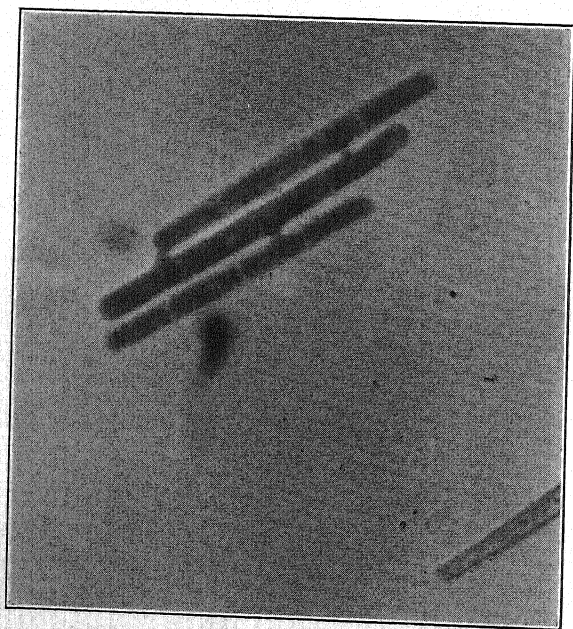


FIG. 4. Photomicrograph of germinating conidia of *Candelospora Citri* showing beginning of anastomosis, \times approx. 1000.

casionally a mount shows a beacon branching laterally from another beacon, the former bearing the conidiophores and conidia. Fructifications also arise directly from the mycelium in the absence of beacons.

The hyphae anastomose freely. The spores begin to germinate either from the end (FIG. 3) or, if lying side by side, may germinate laterally, the germ tubes anastomosing with other spores (FIG. 4). When grown on glucose-potato agar in petri dishes for 9 days at room temperatures of 17° to 21° C., the fungus produced abundant fluffy, cottony growth both in the media and in the air (FIG. 5). Viewed from the top, the color was matched with

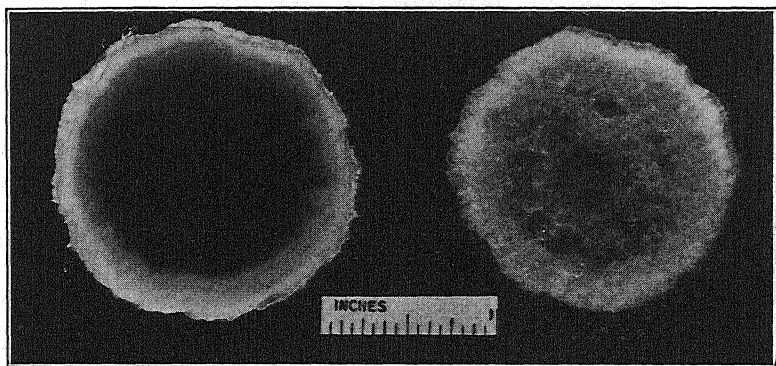


FIG. 5. Colonies of *Candelospora Citri* on dextrose-potato agar. Left, bottom view; right, top view.

Ridgway's cinnamon rufus to hazel; seen from the under side the color was found to vary from hazel to Kaiser brown to hay russet and liver brown.

The genus *Candelospora* is described by Hawley as follows:

Hyphae steriles repentes. Conidiophoris erectis, septatis, hyalinis, irregulariter ramosis vel etiam simplicibus, supra penicillatim divis. Conidiis singulis in *ultimis* ramulis ortis, hyalinis, multiseptatis.

Candelospora Citri sp. nov.

Conidiophores 14 to 23 μ in length, occurring singly or severally on a torch-like hypha which terminates in a swollen cell. Fructification beyond the conidiophore 83 to 93 μ , divided into rami, metulae, sterigmata, and conidia (FIG. 3). Conidia triseptate,

cylindrical, obtuse at the ends, 43 to 48×4.1 to 4.8μ . Torch-like projection 240 to 275μ long and 5 to 6μ wide at base and 2.5 to 3μ wide at narrowest point, with swollen ends 19 to 21×11 to 12.5μ (FIG. 6). No mucus was observed on citrus fruits or on glucose-potato agar.

Habitat.—On decaying fruits of *Citrus sinensis* Osbeck in Florida, U. S. A. Described from cultures on glucose-potato agar,

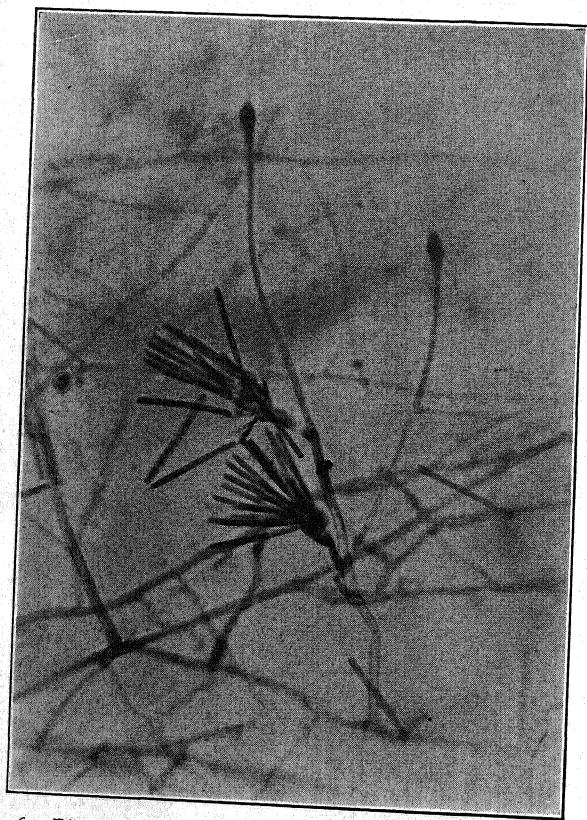


FIG. 6. Photomicrograph of *Candelospora Citri*, \times approx. 300.

dried specimens of which are deposited at the Citrus Experiment Station, Riverside, California; at the United States Department of Agriculture, Washington, D. C.; at the Department of Botany, Harvard University; at the British Museum, South Kensington, England; and at the Imperial Bureau of Mycology, Kew Gardens, Richmond, England.

SUMMARY

A decay of citrus fruits caused by a new species of *Candelospora* was found on an orange fruit at Citra, Florida, in 1932. Inoculations showed the fungus capable of decaying lemons, oranges, and grapefruit, mature fruit being more susceptible than immature fruit.

The fungus grown on glucose-potato agar has an optimum temperature for growth near 25.0° C., a minimum between 7.7° and 11.8° C., and a maximum between 30.4° and 35.0° C.

This fungus differs from *Candelospora ilicicola* Hawley, apparently the only other species of the genus described, in having smaller spores, in having fawn to vinaceous-colored mycelium instead of white tufts, in the lack of mucus in the heads, and in having peculiar aerial hyphae which terminate in swollen cells. Conidiophores grow out laterally from these beacon-like hyphae.

The fungus is described as a new species under the name *Candelospora Citri*.

UNIVERSITY OF CALIFORNIA CITRUS EXPERIMENT STATION,
RIVERSIDE, CALIFORNIA

LITERATURE CITED

1. Anderson, P. J. Rose canker and its control. Mass. Agr. Exp. Sta. Bul. 183: 11-46. 3 pl., 11 fig. 1918.
2. Rea, C. & H. C. Hawley. Fungi. Section 13 of a biological survey of Clare Island, Mayo County, Ireland. Roy. Irish Acad. Proc. 31 (13): 1-26. 1 pl. 1912.
3. Massey, L. M. The crown canker of the rose. Phytopath. 7: 408-417. 3 fig. 1917.
4. Morgan, A. P. Two new genera of Hyphomycetes. Bot. Gaz. 17: 190-191. 2 fig. 1892.

A FUNGUS ON LACE BUGS

VERA K. CHARLES

(WITH 2 FIGURES)

In March of 1935 specimens of lace bugs (*Leptopharsa Heveae* Drake & Poor) on *Hevea brasiliensis* from Para, Brazil, were sent by Dr. C. H. T. Townsend through the Bureau of Entomology and Plant Quarantine to the Division of Mycology and Disease Survey, of the Bureau of Plant Industry, for the determination of a fungus thought to be parasitic on the insects. Observations made by Dr. Townsend indicated that the fungus had been fairly effective in controlling the lace bug which had been causing some concern as a rubber plant pest. He stated that a considerable percentage of the immature stages of the insect had been attacked and killed. Later, Dr. J. R. Weir sent additional specimens of the same insects attacked by this fungus, with the information that the fungus had practically destroyed the bugs over wide areas in certain of the localities where rubber plantings had been made. Additional specimens have been received from time to time from Dr. Weir who has made extensive field observations.

In examining this material it was found that the mycelium of the fungus was especially well developed on the ventral surface of the host (FIG. 1 A) and that the bugs were attached to the lower surface of the leaves by irregularly digitate rhizoids (FIG. 2 C). Instances were observed in which these became septate and the divisions rhomboid and thick walled forming a subiculum-like mass. With a hand lens the fungus covering the insects appeared white to grayish white or pale yellowish in old specimens, which had apparently been attacked when young, and their development inhibited by the presence of the fungus.

In the early stages the mycelium was fine, hyaline and septate, and resembled a net covering the insects. The older hyphae from which the conidiophores developed were fuliginous and more closely septate, and about 8μ in diameter. While the majority of

the hyphae were found to occur singly, strands consisting of 5-12 closely associated, parallel hyphae were also observed. Though no true clavae were found, the strands were sufficient, however, to make evident the stilbaceous nature of the fungus.

The fungus was found in all specimens to be fruiting very sparingly, but it exhibited a remarkable variation in the arrangement of the phialides. In the majority of cases the fructification was seen to be irregularly verticillate, whorls of 3-6 flask-shaped phialides being most common, although instances of opposite phialides were also observed. In addition to these two types of phialide development single phialides were often found occurring at irregular intervals along the mycelium (FIG. 2 *A* and *D*). This particular type suggested the genus *Hirsutella* which in addition to the conidial fructifications on clavae, also develops phialides on individual hyphae. The phialides are flask-shaped, and terminated by a long, filiform sterigma bearing a single oblong spore, but apparently pip-shaped, due to the gelatinous substance which surrounds them. Occasionally a second phialide will develop from the basal cell of the original phialide and produce a spore. Still another variation was observed in which a second sterigma developed from the upper part of the phialide (FIG. 2 *E*). While the wall of the phialide is ordinarily entire in outline, an occasional phialide or group of phialides would be observed with small protuberances on the wall (FIG. 1 *B* and 2 *B*), about 4μ in length. These abnormal phialides were never observed to develop conidia. Because of the marked variation exhibited by the fungus in the method of fruiting it is difficult to suggest a genus sufficiently flexible to include a species presenting such diverse morphological variations in the method of spore production.

In referring to Petch's papers on entomogenous fungi, two species have been noted, *Verticillium hemipterigena* and *Cladobotryum ovalisporum*, which show certain affinities with the fungus on the lace-bug. The first of these was described by Petch¹ in 1932 from material of leaf hoppers on bamboo from Ceylon. This was stated to be the conidial stage of *Torrubiella hemipterigena* Petch. The conidial form of this fungus bears a close resemblance

¹ Petch, T. Notes on entomogenous fungi. Trans. Brit. Myc. Soc. 16: 236. 1932.

to the species under consideration, but differs in the size and shape of the conidiophores, phialides and spores. The conidiophores are described as up to $150\ \mu$ long, and $1.5\ \mu$ in diameter, while the

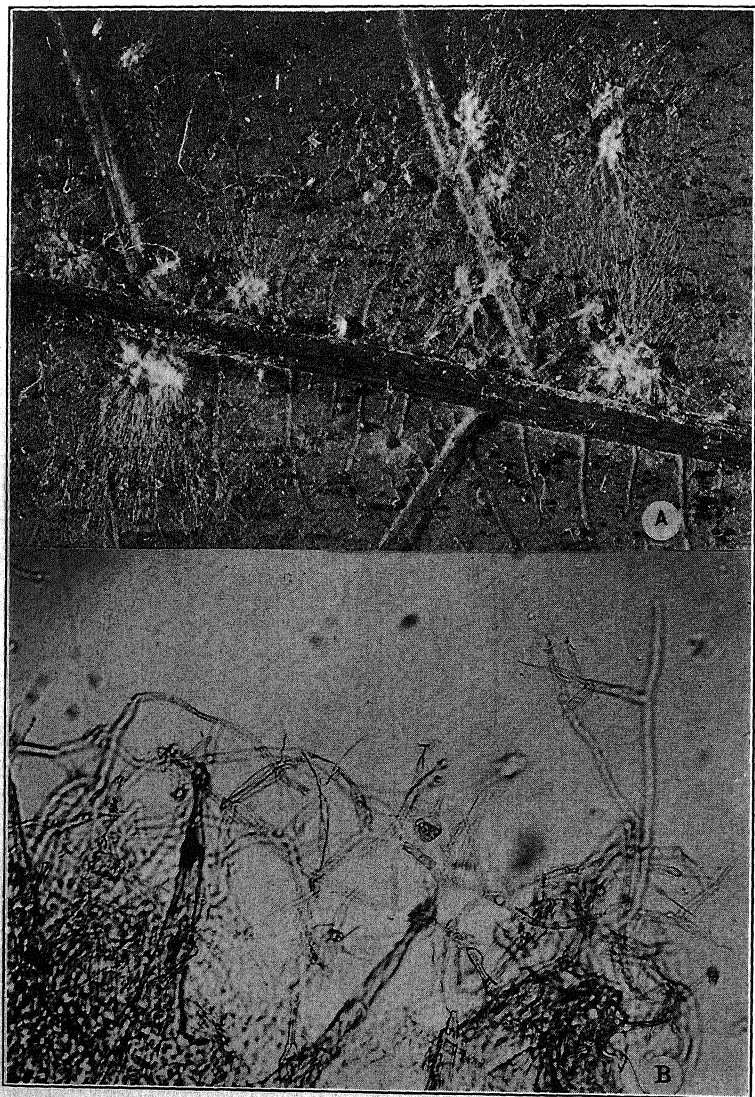


FIG. 1. A, part of rubber leaf showing lace bugs attacked by *Hirsutella verticillioides*, $\times 5$; B, photograph of hyphae showing phialides with projections on the walls, $\times 250$.

conidiophores of the lace bug fungus range from 100–450 μ in length.

The phialides of *Verticillium hemipterigena* are described as 12–16 μ long, 1 μ diameter below, the conidia narrow-oval or fusoid or sub-falcate, ends acute hyaline continuous $5-8 \times 1 \mu$ usually solitary, occasionally two in a parallel bundle. In the species on lace bugs the flask-shaped portion of the phialides is $4-7 \times 20-28 \mu$. The spores are $4-5 \times 6-8 \mu$.

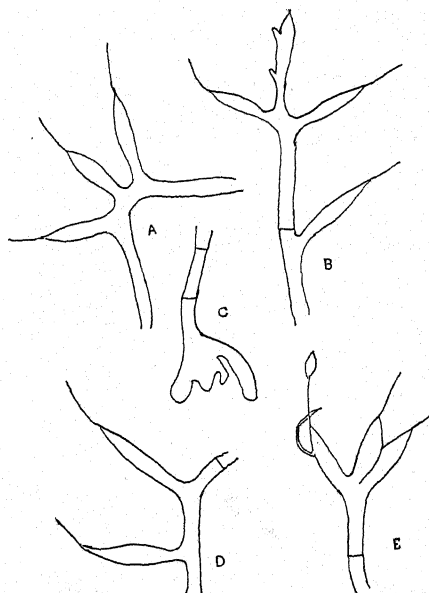


FIG. 2. Camera lucida drawings of *Hirsutella verticillioidea* showing, A and D, development of single phialides; B, phialide showing protuberances on the wall; C, rhizoids; E, development of a second sterigma on the phialide. $\times 350$.

In the same paper Petch (l. c., p. 230) described the second fungus *Cladobotryum ovalisporum* from material on frog hoppers from Ceylon. This fungus is described as having conidiophores up to 320 μ high, 2 μ in diameter below, the phialides up to five in a whorl, narrow flask-shaped, 5–8 μ long, 1–1.5 μ in diameter below and bearing minute cylindrical sterigmata, usually simple, sometimes bifurcate, toward the apex. While the sterigmata suggest the projections (FIG. 1 B and FIG. 2 B) on the phialides of the

fungus studied here, they are much smaller and more cylindrical. The conidia are also shorter ranging from $3-5 \times 1.5-2 \mu$.

The fungus on lace bugs is remarkable for the great variation in the size of its conidiophores and phialides. Fruiting is more abundant in the young growing area, but the conidiophores are smaller, more flexuous and graceful than those developed from the older hyphae. In the latter case the conidiophores are stouter, erect, rigid and with fewer whorls of phialides.

In view of the striking variations exhibited by the lace bug fungus its taxonomy is debatable. The shape of the phialides, the long sterigma and the character of the spores suggest the genus *Hirsutella*, but the verticillate arrangement of the phialides is characteristic of *Verticillium* and *Cladobotryum*. However, our study of the available material leads us to the conclusion that the organism has more affinities with the genus *Hirsutella* than with *Verticillium* or *Cladobotryum* and we are therefore designating it *Hirsutella verticillioides* with the following description:

***Hirsutella verticillioides* sp. nov.**

Mycelium producing a film over the insects, white later pale yellow, hyphae erect or decumbent, branched, older coarse thick-walled $6-10 \mu$ in diameter, short septate, pale fuliginous, $5-12$ fasciculate; conidiophores erect, rigid, simple, septate, tapering, hyaline above, fuliginous below, $100-450 \mu$ in height; phialides $3-6$ verticillate, flask-shaped, $4-7 \times 20-28 \mu$, attenuated into a sterigma $8-15 \mu$ in length; conidia apical, hyaline, oval but apparently pip-shaped due to a gelatinous substance which surrounds them, $4-5 \times 6-8 \mu$; rhizoides digitate sometimes septate, cells becoming thick-walled and rhomboid.

Mycelio insectum membrana obducente, primo albo dein pallide flavido, hyphis repentibus v. erectis, septatis, ramosis, vetustis muris incrassatis, $6-10 \mu$ diam. breve septatis, pallide fuligineis, $5-12$ -fasciculatis; conidiophoris erectis, rigidis, simplicibus, septatis, attenuatis, infra fuligineis, supra hyalinis, $100-450 \mu$ alt.; phialidibus $3-6$ -verticillatis vel singulis, lageniformibus, $4-7 \times 20-28 \mu$, sterigmati $8-15 \mu$ longo; conidiis acrogenis, hyalinis, ovalibus, propter substantiam gelatinosum circumvallentem pseudolimoniformibus, $4-5 \times 6-8 \mu$; rhizoidibus digitatis, interdum septatis, cellulis rhomboideis, muris incrassatis.

In *Leptopharsam Heveae* in foliis *Heveae brasiliensis*, in Brasilia.

Type: Communicated by A. Johnston, Para, Brazil, July, 1935, in Mycological Collections of the Bureau of Plant Industry, No. 70902. Portions of this collection also deposited in the Farlow Herbarium of Harvard University, the University of Michigan Herbarium, and the New York Botanical Garden Herbarium. Additional collections (Myc. Coll. Nos. 70903, 70904) received from J. R. Weir, Para, Brazil, April 8 and May 14, 1936.

BUREAU OF PLANT INDUSTRY,
U. S. DEPARTMENT OF AGRICULTURE,
WASHINGTON, D. C.

A NEW SPECIES OF MAGNUSIA¹

L. M. AMES

(WITH 14 FIGURES)

The interesting fungus considered and illustrated in the present note is a dung-inhabiting member of the Aspergillaceae. The substratum, horse dung, upon which it was first found by the writer, was collected in the spring of 1934 in The Great Smoky Mountains in Tennessee on Gregory Bald, near the North Carolina State line.

For nearly two years pure cultures have been maintained on agar media containing a small amount of potato broth and horse-dung extract. On the same media pure cultures of *Magnusia nitida*² have been grown for the purpose of comparison. Observations and comparisons of both species have been made under similar growing conditions.

If one disregards the conspicuous appendages of *Magnusia nitida* and *Magnusia* sp. described below, it is at once apparent that in size and shape the perithecia of both species are indistinguishable, and indeed their asci, spores, and conidia are similar in size and color. However, even a macroscopic examination will suffice to distinguish the two species when their prominent appendages are taken into consideration. The copious, elevated clusters of elongate appendages give the perithecia of *M. nitida* a distinctly bushy appearance, while in contrast the fewer, much shorter, and more regularly coiled appendages decorate the perithecia of the latter species in a much less showy manner. The conspicuous differences in the length of appendages, the amount of their coiling, and the average number produced, convinced the writer that the fungus herein described is quite distinct and worthy of designation.

¹ Contribution from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University No. 143.

² Cultures obtained from Mr. Herman R. Sweet of the Biological Institute, Harvard University.

as *Magnusia brachytricha*; the specific name referring to the short, rigid hairs ornamenting the perithecia.

***Magnusia brachytricha* sp. nov.**

Perithecia superficialia, non ostiolata, oblonga, obtuse triangularia vel quadrangularia, $125-325 \times 100-225 \mu$, nigra, primum pilis longis tenuibus flexuosis pallidis circiter $175 \times 2 \mu$ maturitate evanescentibus aequaliter vestita, in uno vel pluribus locis pilis conspicuis rigidis circinatis septatis lucide nigris $1-5$ -fasciculatis $5-8 \mu$ latis et $50-150 \mu$ longis e cellulis interioribus parietis manifeste cellularis orientibus ornata. Asci numerosi, globosi ($10-13 \mu$ diam.) vel oblongo-pyriformes ($18-22 \times 10.5-12.5 \mu$), sporis ellipsoideis, utrinque acutis $6-8 \times 3-5 \mu$ primum hyalini, demum dilute flavofusci. Conidia ellipsoidea, utrinque acuta, $4.5-5 \times 2.2-2.5 \mu$, coremio insidentia.

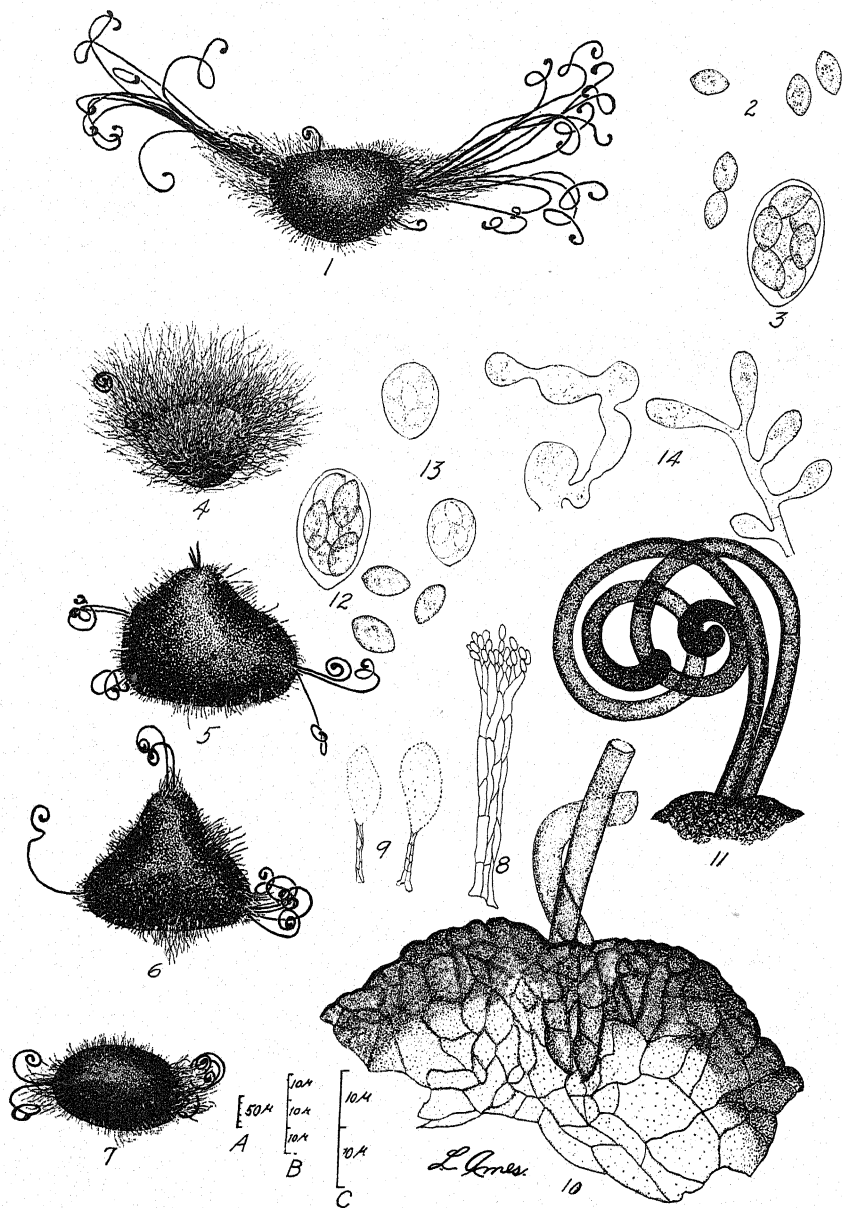
Magnusae nitidae Sacc. arcte affinis sed pilis circinatis multo brevioribus diametrum perithecii non aequantibus facile distinguitur.

Perithecia superficial, non-ostiolate, oblong, obtuse triangular or quadrangular, $125-325 \times 100-225 \mu$, black, at first covered with long, flexuous, light-colored hairs about $175 \times 2 \mu$ which disappear at maturity. Perithecia at one or several points ornamented with conspicuous, stiff, shiny-black circinate, septate hairs $1-5$ -fascicled $5-8 \mu$ wide and $50-150 \mu$ long, originating from internal cells of the perithecial wall. Asci numerous, globose ($10-13 \mu$ diam.) to oblong-pyriform ($18-22 \times 10.5-12.5 \mu$), 8-spored, spores ellipsoid, acute at both ends, $6-8 \times 3-5 \mu$, at first hyaline, becoming dilute yellowish-brown. Conidia ellipsoid, acute at both ends, $4-5 \times 2-2.5 \mu$, borne on a coremium.

Magnusia brachytricha is easily distinguished from *M. nitida* Sacc. by the circinate hairs which are usually shorter than the diameter of the perithecium.

Type: pure cultures deposited in the Farlow Herbarium, Harvard University. Pure cultures also deposited in the Herbarium of the Division of Mycology and Disease Survey, U. S. Department of Agriculture, Washington, D. C. The species was developed on horse dung which was collected on Gregory Bald in The Great Smoky Mts. in Tennessee.

In the fall of 1935 the writer was given a small portion of a *Magnusia* which had been cultivated by Dr. W. W. Diehl of the Division of Mycology and Disease Survey, U. S. Department of Agriculture, Washington, D. C. This particular *Magnusia*, iden-



FIGS. 1-3, *Magnusia nitida*; 4-14, *Magnusia brachytricha*.

tical with *M. brachytricha*, came from bear dung which was collected on Grandfather Mountain, North Carolina, in June 1927. A small portion of this material which the writer placed in an agar plate produced mycelia after six or seven days and matured perithecia about two weeks later. The delay in growth and fruiting was probably due to the extremely desiccated condition of the herbarium specimen, for subsequent transfers came into fruiting much sooner. It is interesting to note that Diehl's specimen was able to revive and fruit after having been in the herbarium for about seven years.

In addition to the collection made by Diehl in 1927, evidence of a still earlier collection of *Magnusia brachytricha*, but recognized only as *M. nitida*, is obtained from figures in Mycotheca Marchica, Zoph and Sydow, No. 100; the central figure is unquestionably that of *M. nitida*, but the other two perithecia illustrated certainly resemble *M. brachytricha*.

In conclusion I wish to thank Dr. William W. Diehl for the herbarium specimens of his 1927 *Magnusia* isolation. I am particularly grateful to Mr. Alfred Rehder for giving me valuable assistance in the writing of the Latin description, and to Dr. William H. Weston for his interest and helpful criticism.

EXPLANATION OF FIGURES

Fig. 1-3, *Magnusia nitida*: 1, Mature perithecium showing long, circinate appendages and remnants of flexuous hairs; illustrated here for comparison with *M. brachytricha*; 2-3, mature ascospores and ascus with contained ascospores. Fig. 4-14, *Magnusia brachytricha*: 4, young perithecium covered with long, flexuous, light-colored hairs; 5-7, mature perithecia showing variation in shape and size; note also remnants of flexuous hairs (the perithecia illustrated were grown on agar and therefore retain considerable fragments of the flexuous hairs; on dung these hairs wholly disappear); 8, a coremium showing colorless conidia at apex; 9, conidial clusters borne on coremia; 10, section showing origin of ornamental hairs from internal cells of the perithecial wall; 11, detail of rigid, ornamental hairs showing septations; 12, mature ascus and ascospores; 13, two immature asci containing undeveloped ascospores; 14, stages in the development of ascogenous hyphae drawn from fresh material which was slightly stained with basic methylene blue. Fig. 1, 4-7, and 9 drawn to scale A; fig. 8 and 11 drawn to scale B; fig. 2-3, 10, and 12-14 drawn to scale C.

SOME SPORANGIAL VARIATIONS IN SAPROLEGNIA FERAX

FRED T. WOLF

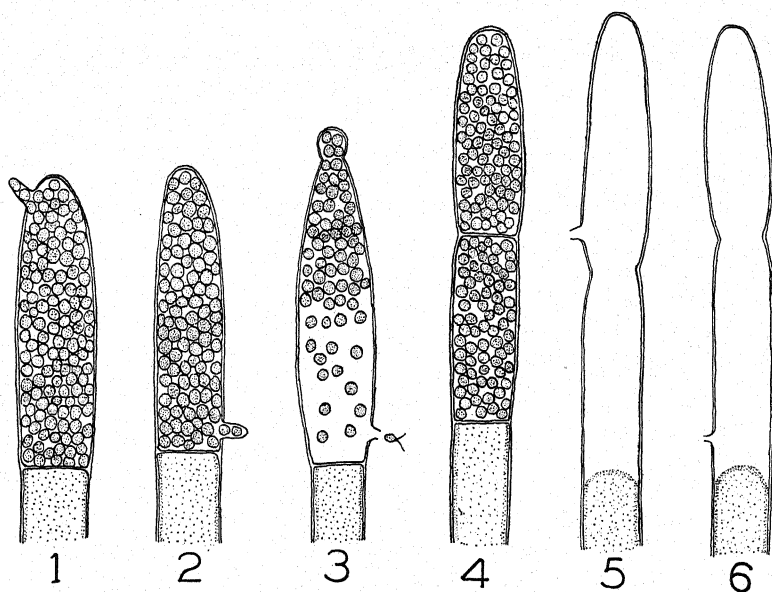
(WITH 6 FIGURES)

It is probably because generic distinctions within the Saprolegniaceae are based largely on sporangial characters that attention has been directed toward morphological variations in these structures. Horn (3) induced the production of both terminal and intercalary sporangia with lateral openings in *Achlya polyandra* by the use of high temperatures and dilute solutions of metallic salts. Lechmere (4) states: "As the result of keeping a species of *Saprolegnia* under observation for a period of five months it has been possible to obtain on the same mycelium the methods of asexual reproduction which are characteristic of six different genera." Similar results were obtained with an undetermined species of *Saprolegnia* by Collins (2), who regards her fungus as being probably identical with *S. Thureti* deBary (*S. ferax* (Gruith.) Thuret). Coker (1) points out, however, that such resemblances to other genera are merely superficial, and do not imply, as Lechmere maintained, that the accepted classification of the group is invalid. Coker also enumerates the sporangial variations which have been reported for a considerable number of species.

The occurrence of two sporangia, one below the other, terminating the hyphal tips of *S. ferax* was described by Lechmere (5) in 1911, but has apparently not been mentioned by subsequent authors. This rather rare abnormality was recently observed in hempseed cultures of two strains of *S. ferax*, one isolated on corn grains from tanks in the greenhouse of the Biology Building, University of Wisconsin, on January 15, 1936, and the other collected at the Limnological Laboratory at Trout Lake, Wis., on July 22, 1936. Although the majority of the sporangia produced were of the primary type described as being typical of this species, in about 10 per cent of the cases secondary sporangia were formed

(FIG. 4), their development being of the basipetal type of Lechmere.

Several instances were noted (FIG. 1-3) in primary, apparently typical sporangia in which the papilla through which the zoöspores emerged was formed at various points on the lateral walls of the sporangium rather than at its tip. Such abnormally located papillae were more frequently observed near the base of the sporangium (FIG. 2) than elsewhere. (FIG. 2) than elsewhere.



FIGS. 1-6. Sporangia of *Saprolegnia ferax*.

Lechmere (5) figured the discharge of both the terminal and subterminal sporangium as occurring by means of a terminal papilla in the terminal sporangium, the subterminal sporangium discharging its zoöspores following dissolution of the wall separating the two sporangia. The variations noted above concerning the place of papilla formation in primary sporangia were also observed in secondary sporangia (FIG. 5, 6). In some cases the subterminal sporangium was the first to discharge.

Apparently, therefore, in *S. ferax* sporangia may be produced and discharge in a number of different ways, which are probably determined, at least in part, by external conditions.

The writer wishes to express his appreciation to Dr. E. M. Gilbert for his advice and criticisms in connection with this work, which was supported by a grant from the Wisconsin Alumni Research Foundation.

UNIVERSITY OF WISCONSIN,
MADISON, WIS.

LITERATURE CITED

1. Coker, W. C. Two new species of water molds. *Mycologia* 6: 285-302. 1914.
2. Collins, M. I. Note on certain variations of the sporocyst in a species of *Saprolegnia*. *Proc. Linnean Soc. New South Wales* 45: 277-284. 1920.
3. Horn, L. Experimentelle Entwicklungsänderungen bei *Achlya polyandra* deBary. *Ann. Myc.* 2: 207-241. 1904.
4. Lechmere, A. E. An investigation of a species of *Saprolegnia*. *New Phytol.* 9: 305-319. 1910.
5. —. Note sur les variations observées dans deux espèces de *Saprolegnia*. *Bull. Mus. Hist. Nat. Paris* 17: 376-381. 1911.

NEW ZOOPAGACEAE DESTRUCTIVE TO SOIL RHIZOPODS

CHARLES DRECHSLER

(WITH 6 FIGURES)

Three species of *Cochlonema* and one species of *Zoopage* are newly described herein, increasing the recorded membership of the Zoopagaceae from 22 to 26. Observations on sexual reproduction in two of the new species of *Cochlonema* now remedy in some degree the inadequacy of detail in the knowledge hitherto available on zygospore formation in that genus. Biological interest attaches perhaps more especially to the other two forms, inasmuch as they subsist on testaceous rhizopods, rather than on *Amoebae* or nematodes, which between themselves provide the source of nourishment for all organisms previously assigned to the family.

COCHLONEMA ODONTOSPERMA

A fungus conspicuous among conidial Phycomycetes for the distinctive sculpturing of its zygosporangia was observed in more than a dozen old maize meal agar plate cultures. All of the cultures in question had been used in the isolation of species of *Pythium* from diseased portions of seed plants, some having been started with decaying parts of water-lily (*Nymphaea odorata* Ait.) leaves collected near Butternut, Wis., late in July 1935, and others with decaying pieces of stems and roots cut from tomato (*Lycopersicon esculentum* Mill.) plants found wilting in the greenhouse early in December 1935. To each of the cultures had been added, besides, pinches of leaf mold taken from supplies of this material collected during July 1935, partly in deciduous woods near Cumberland, Md., and partly in coniferous woods near Butternut, Wis. As the fungus, wherever observed in its earlier development, always began spreading over the substratum from a deposit of leaf mold, its presence in the cultures must have been attributable to



FIG. 1. *Cochlonema odontosperma*.

the forest refuse rather than to the pieces of freshly decaying herbaceous tissue. Whenever encountered it subsisted exclusively as a parasite on what appeared to be a single species of *Amoeba* that, in an approximately rounded shape, measured mostly from 30 to 60 μ in diameter. Although the finely granular protoplasm of the newly infected animals was not unfavorable for microscopic examination, a body of dimensions and structure to encourage interpretation as a nucleus could not usually be made out as clearly as might be desired. An ellipsoidal inclusion discerned in some invaded specimens and revealing a darkish peripheral layer with lumpy thickenings protruding inward (FIG. 1, A), appeared the most persuasive among the likely structures that came under observation. Possibly the same structure in a pathological condition may have been represented in a body of comparable size, showing a layer of separate peripheral granules suggestive of chromatin particles, that was seen in some nearly depleted animals (FIG. 1, D). With either type of peripheral organization, interpretation was embarrassed by the presence frequently of digestive vacuoles somewhat similar in dimensions, in shape and occasionally even in arrangement of contents; so that for the time being the specific identity of the susceptible animal remains, unfortunately, very uncertain.

Infection of the *Amoeba* is initiated when an adhering conidium thrusts a germ tube through the pellicle and a short distance into the protoplasmic interior. At the tip of the germ tube a globose swelling then puts into appearance (FIG. 1, A) and increases in size with the transfer to it of the conidial contents. Completion of the transfer is followed by disarticulation of the globose body, which immediately begins autonomous development, while the empty envelope of conidium and germ tube is promptly expelled. Invasion thus follows the course set forth with more attention to detail in my description of *Endocochlus asteroides* (1) and *E. gigas* (2). Just as in the two species mentioned, the vegetative body here develops as a thick filament, which, whether simple or dichotomously branched, is coiled in a handsome cochleate spiral of one to two turns. Because in this species an empty conidial membrane has never been seen attached to a convolved thallus, separation from the two congeneric forms I described earlier (1)

as *Cochlonema verrucosum* and *C. dolichosporum*, which regularly show such attachment, entails no difficulty.

That the fungus is, indeed, a third member of the genus *Cochlonema*, is plainly revealed in its asexual reproduction. The conidiiferous hyphae are proliferated radially from the outer contour of the spiral body, the one first produced arising close to or often directly from the place of original attachment, and additional ones arising at intervals mostly of 3 to 10 μ in positions successively closer to the growing extremity (FIG. 1, B-F). Naturally the number of such hyphae is variable: a poorly developed thallus that has shared the nourishment available in a small animal with several fellows may produce only a single conidiiferous filament (FIG. 1, E), whereas five (FIG. 1, B), six (FIG. 1, D) or even more may originate from relatively massive vegetative bodies. If the host dies submerged in the substratum, the filaments make their way to the surface, where differentiation somewhat gradually becomes evident in slightly increased width, in regularly spaced constrictions, and in perceptible verrucose sculpturing. The conidia resulting from evacuation of the constrictions and delimitation of the separated protoplasts by end walls, are thus distinguished by minutely warty contours (FIG. 1, F, G, H). Such sculpturing may be virtually absent, however, in the small admixture of longer and narrower spores resulting from segmentation of the little differentiated proximal portions of the aerial prolongations. Since branching occurs, though, of course, not profusely, in the sporogenous portions of the filaments as well as in the sterile submerged portions (FIG. 1, F), branched conidia are occasionally to be found (FIG. 1, H).

Sexual reproduction takes place in some quantity usually during the later stages of an epizoötic, when conidia are strewn about in such abundance that plural infections frequently occur with the result that many individual animals come to harbor two or more thalli of the consistently dioecious parasite. In position of origin the zygophoric hyphae are similar to the conidiiferous filaments, which, moreover, in their proximal portions they exceed little in width. After attaining some length, and especially on passing through the pellicle of the host, they usually widen markedly; further elongation with some bending thereupon bringing about

apical union in pairs, followed soon by fusion (FIG. 2, C, a). Some zygophoric hyphae, to be sure, fail to find an unengaged mate (FIG. 2, A, e, f, g; C, e), and then may continue to grow a little, often with the bizarre erraticness elsewhere familiar in instances of such frustration. Now and again three sexual hyphae, with a fine disregard of propriety, come together in a triple union (FIG. 2, A, d). In any case, conjugation is followed by the budding forth of a globose excrescence from one of the hyphae, generally at some distance from the union (FIG. 2, A, a-d). This excrescence, the young zygosporangium, remains smooth until about fully grown, when 20 to 35 warty prominences appear on the spherical surface (FIG. 2, B, a-d), soon to become modified individually like the crown of a grinding tooth with two, three or four recognizable cusps (FIG. 2, C, b-d). The decided increase in thickness of wall that takes place during maturation (FIG. 2, D, a-d; E, a-f) is no doubt to be attributed to the deposition of a zygospor wall proper, which, at least under the difficult optical conditions brought about by the pronounced sculpturing, appears indistinguishably fused with the zygosporangial envelope.

An epithet composed of two words meaning "tooth" and "seed" respectively, would seem appropriate for the fungus.

Cochlonema odontosperma sp. nov.

Hyphae alitae 4-10 μ crassae, simplices vel semel vel bis dichotomae, semel vel bis spiraliter convolutae. Conidia cylindracea, utrimque attenuata, rarius paulo ramosa, plerumque minute verrucosa, 8-36 μ longa, 1.2-2.0 μ crassa, in catenulas saepe 10-30-sporas digesta. Hyphae zygosporiferae 20-45 μ longae, basi 1-1.5 μ crassae, sursum 3-4 μ crassae, utraque ex alia hypha alita enata. Zygosporangia sphaeroidea, 8-10 μ diam., membrana 20-35 dentibus columellaribus, minute bicornibus vel tricuspidibus vel minute quadrifidis, 1-1.5 μ altis et latis ornata. Zygosporae paulo flavidae, membrana circa 1-1.2 μ crassa cum membrana zygosporangii verisimiliter concreta, quacum conjunctim loculum 6-7 μ diam. circumdat.

Amoebas 30-60 μ latas enecans et consumens, habitat in humo silvarum prope Cumberland, Maryland, et Butternut, Wisconsin.

Vegetative hyphae 4 to 10 μ in diameter, frequently simple or once bifurcate, but only rarely twice bifurcate, coiled beautifully in a spiral of 1 to 2 turns. Conidia cylindrical, tapering at both ends, rarely branched, mostly minutely warted, 8 to 36 μ , mostly 10 to 20 μ (average 16 μ) long, and 1.2 to 2 μ (average 1.6 μ)

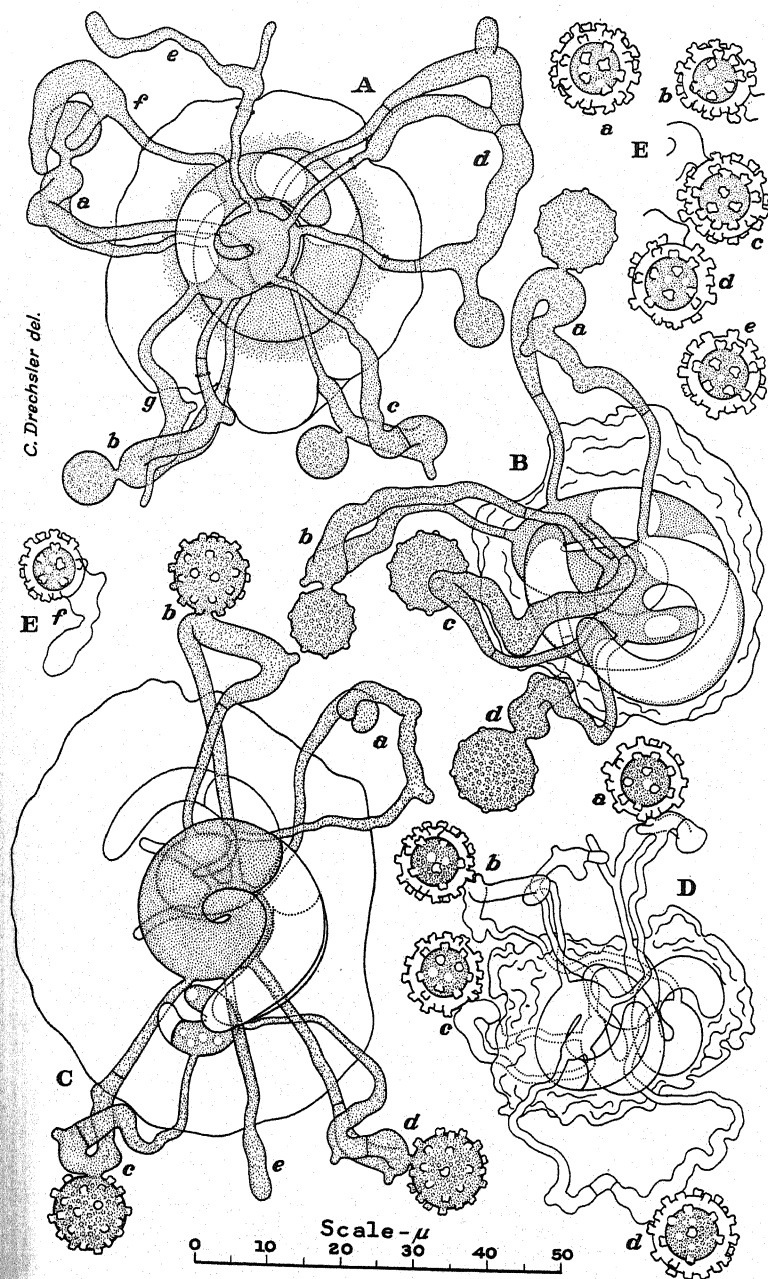


FIG. 2. *Cochlonema odontosperma*.

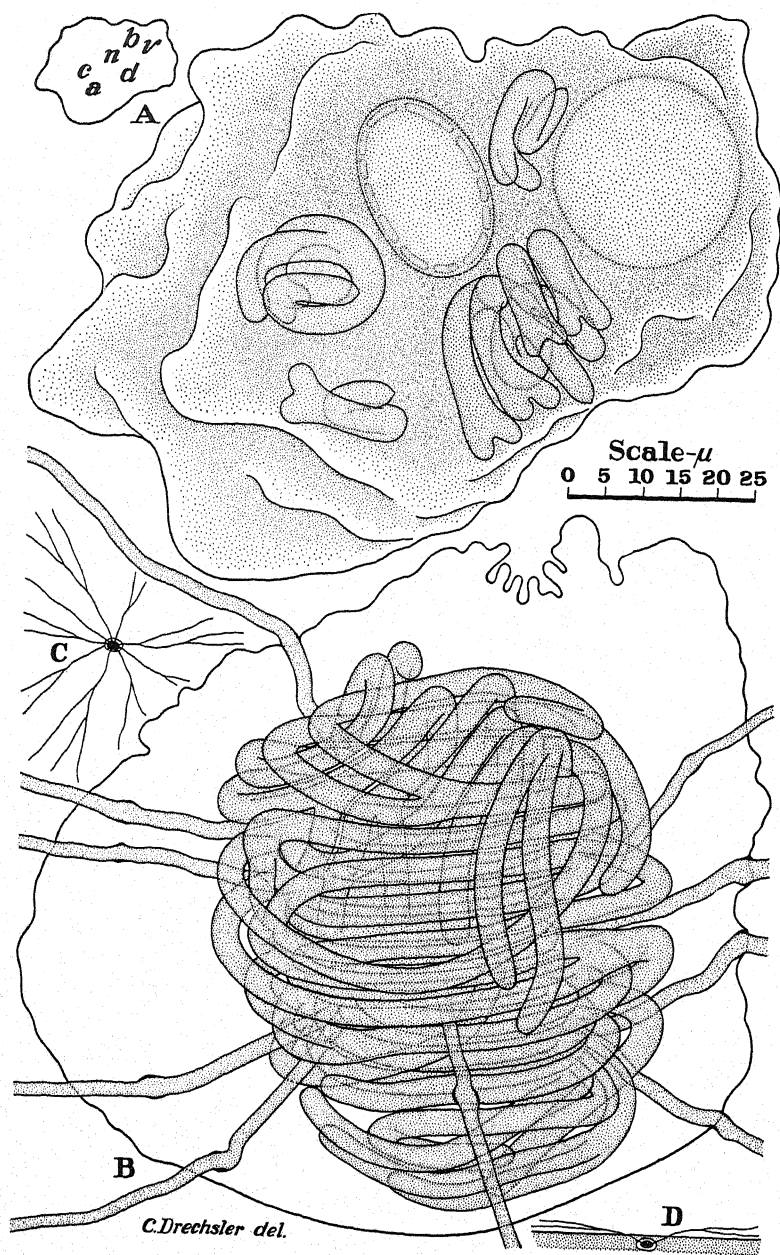
wide, formed in chains in numbers varying mostly from 10 to 30. Zygophoric hyphae 20 to $45\ \mu$ long, 1 to $1.5\ \mu$ wide at the base and 3 to $4\ \mu$ toward the distal end, each of a conjugating pair arising from a separate assimilative hypha. Zygosporangium subspherical, 8 to $10\ \mu$ in diameter, its membrane ornamented with 20 to 35 columnar toothlike protuberances, mostly 1 to $1.5\ \mu$ in height and in width, and bearing 2, 3 or 4 minute cusps. Zygospores somewhat yellowish, having a proper wall perhaps about 1 to $1.2\ \mu$ in thickness, that appears indistinguishably adnate to the zygosporangial membrane, together with which it surrounds a locule 6–7 μ in diameter.

Occurring in leaf mold, infecting and consuming *Amoebae* 30 to $60\ \mu$ in diameter, near Cumberland, Md., and Butternut, Wis.

COCHLONEMA MEGASPIREMA

Of the three species of *Endocochlus* hitherto described, *E. gigas* is easily the most impressive, surpassing its two known congeners in the bulk and elaborately helicoid convolution of its thallus, as well as in the abundance of sexual and asexual reproductive apparatus produced therefrom. This luxuriance, as was pointed out in the original description, is made possible by the size and substantial composition of the host animal, *Amoeba terricola* Greef (*sensu strictiore*), a rhizopod, which, if not strictly of rare occurrence in old agar plate cultures, certainly does not seem to develop there in considerable numbers as frequently as might be expected from its reputedly general distribution in the soil. The animal, easily identified by the characteristic structure of its large nucleus (FIG. 3 A, n) was observed in quantity in some plate cultures as one of the numerous organisms superimposed on *Pythium* mycelia that had promptly grown out from decaying pieces of leaves of the white water lily collected near Butternut, Wis., late in July 1935. To a number of cultures thus infested were added some pinches of partly decayed tomato leaves picked up from the ground in a greenhouse near Beltsville, Md. In these cultures, two weeks later, the entire population of the rhizopod, consisting perhaps of a hundred individuals, was being exterminated by an endoparasite of most extraordinary appearance.

Development of the parasite begins, as could be determined from observations on a few favorable incipient infections, much like

FIG. 3. *Cochlonema megaspirema*.

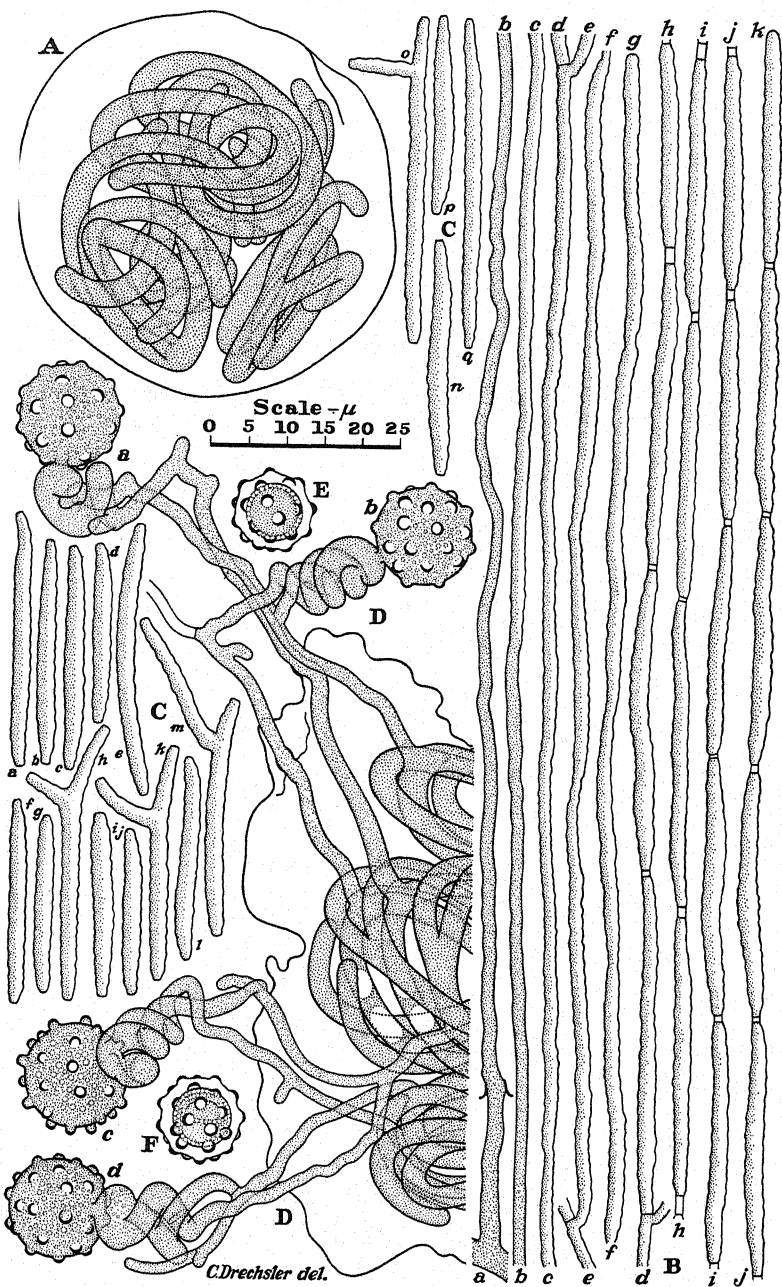
development of *Endocochlus asteroides*, *E. brachysporus* Drechsl., *E. gigas* and *Cochlonema odontosperma*: a germ tube, thrust into the animal by an adhering conidium, giving rise to an apical globose body, which, after receiving all the conidial contents, becomes detached to proceed with autonomous growth. On attaining a length of approximately $10\ \mu$ the young thallus, like the thalli of other endoparasitic members of the Zoöpagaceae, curves abruptly to commence the spiral windings that thereafter are continued until the protoplasmic materials of the host are finally exhausted. However, while in the other endoparasitic forms a marked widening of the thallus is evident at the first turn if not before, in the present species the filament maintains an approximately constant width little greater than that of the newly disarticulated globular body. The much greater length of filament thus made necessary contributes to more frequent branching and to far more elaborate coiling; so that vegetative bodies with one to two bifurcations and as many turns (FIG. 3, *A*, *a*, *b*, *c*) represent very early stages of development, and even a thallus with two successive turns and three successive dichotomies (FIG. 3, *A*, *d*) may be still relatively immature. When a single thallus has completed appropriation of the contents of a large animal (FIG. 3, *B*), it appears as an intricate mycelial coil too thick to be seen through, though the elements exposed to view in the upper aspect and at the periphery indicate sufficiently that the number of successive dichotomies certainly can not be less than four or five. Of course, much less impressive development results when a number of thalli share the contents of a relatively small host animal (FIG. 4, *A*).

Asexual reproduction always takes place in quantity, beginning as soon as the host animal has been brought to a stop, usually at some depth in the agar substratum. Even while the last protoplasmic remnants of the *Amoeba* are being appropriated, a number of filaments are put forth from the coiled thallus. These perforate the substantial pellicle of the host after the manner of an appressorium, and then continue to elongate toward the surface of the substratum, their contours becoming in increasing measure irregularly and minutely warty (FIG. 4, *B*, *a-c*). After emergence into the air, elongation is continued in a nearly horizontal direction (FIG. 4, *B*, *c-d*) until a length usually of several milli-

meters has been reached (FIG. 3, C, D). Sporulation thereupon takes place as in other catenulate members of the family, that is, through the withdrawal of contents from the short, slightly constricted isthmi perceptible at rather regular intervals in the aerial prolongations (FIG. 4, B, e-g), followed by the laying down of septa at both ends of the protoplasts thus separated (FIG. 4, B, d-k). Frequently a proximal part of an aerial prolongation is not immediately converted into conidia, instead growing out anew from below the lowermost conidium to give rise to a filament that in due course similarly yields a chain of spores. Repetition of the same process several times in each of the hyphal outgrowths coming from the thallus, in the end brings about a somewhat arachnoid display of catenated conidia with a total bulk seemingly far in excess of what might be expected from the volume of the underlying vegetative coil, even though this volume is in many instances obviously very considerable.

In general appearance the conidia (FIG. 4, C, a-q) bear most resemblance to those of *Zoopage phanera* Drechsl., though usually they are somewhat shorter and noticeably more coarsely sculptured. Their slightly tapering and bluntly rounded or truncate ends recall *Z. nematospora* Drechsl., and, as in the latter species, the little constricted empty connections between the members of a chain reveal the mode of sporulation with satisfying clearness.

Sexual reproduction took place in only one of the cultures, and there only very sparingly. The process shows similarity to that set forth in my description of *Bdellospora helicoides*, the distally widened zygothoric hyphae, of which each in a pair arises from a separate thallus, becoming interinvolved in a few helicoid turns. One of the conjugating hyphae is usually somewhat in advance of its mate, and thus alone provides the forefront of the interinvolved helices from which the zygosporangium buds forth as a sessile globose excrescence (FIG. 4, D, a-d). The fully grown zygosporangium, like the homologous structure of *B. helicoides* is ornamented with warty protuberances. In spite of diligent search it was not possible to find mature sexual apparatus whose connection with the fungus under consideration was attested by positional relationship to a pellicle recognizable as pertaining to *Amoeba terricola*. A single cluster of mature zygosporangia encountered after

FIG. 4. *Cochlonema megaspirema*.

the disappearance of the pellicle had made their identification uncertain, probably belonged to the parasite even though their dimensions were somewhat smaller than might have been expected. They showed a thick zygosporangial wall, which, fused indistinguishably with the warty zygosporangial envelope, inclosed a locule containing a parietal layer of coarse granules and a large central reserve globule (FIG. 4, E, F).

While I was a student in the Cryptogamic Laboratories of Harvard University 20 years ago, the late Professor Thaxter took occasion to show me under his microscope a very well developed thallus either of the present fungus or of a fungus exceedingly similar to it. In reply to an inquiry as to the nature of so amazing a structure he remarked that "Its name is enigma." The meager information I retained of the incident, on which, nevertheless, Dr. W. H. Weston and Dr. D. H. Linder acted with much kindness, proved insufficient to locate the preparation in the collections left at Harvard by the distinguished mycologist. It seems probable that the specimen shown me in 1916 appeared adventitiously in a mount of some other fungus, perhaps when the living material had already been discarded, giving no opportunity for relating the curious thallus to a spore form, or even for identifying the substantial enveloping membrane as the pellicle of a parasitized terricolous *Amoeba*. As Thaxter demonstrably used an unpublished term "Aenigma" in a sense quite alien to any possible application suggested in the oral remark quoted above, a name made up from two words meaning "large" and "coil" respectively, is proposed for the fungus.

***Cochlonema megaspirema* sp. nov.**

Hyphae alitae 2.5–4.5 diam., saepe, praecipue ubicumque solitariae in animalibus magnis luxuriantes, longae, quater vel quinquies repetite dichotomae, in spiram miram circumplicantes. Conidia verrucosa, anguste cylindracea vel filiformia, interdum ramosa, utrimque paulo attenuata, 20–45 μ longa, 1.6–3 μ crassa, in catenulas longas, simplices vel furcatas digesta. Hyphae zygosporiferae circa 50–80 μ longae, deorsum interdum aliquam ramosae et circa 2 μ crassae, sursum circa 4 μ crassae et binae inter se bis vel quater spiraliter circumplicantes. Zygosporangia 10–15 μ diam., flavida, 20–30 verrucis .8–1.5 μ altis 1.5–2 μ latis ornata.

Amoebam terricolam (sensu strictiore) enecans, habitat in foliis semiseputis putrescentibus *Lycopersici esculenti*, prope Beltsville, Maryland.

Vegetative hyphae 2.5 to $4.5\ \mu$ (average $3.6\ \mu$) in width, often and more especially on developing singly in large animals, conspicuously long, repeatedly bifurcate 4 or 5 times and wound rather compactly in coils of numerous individual turns. Conidia distinctly warty, narrowly cylindrical or filiform or sometimes branched, slightly tapering toward the ends, 20 to $45\ \mu$ (average $31\ \mu$) long and 1.6 to $3\ \mu$ (average $2.3\ \mu$) wide, produced in numbers up to 50 or more in long, simple or branched chains, wherein they are separated from one another by evacuated portions of filament usually about $1.3\ \mu$ wide and $.5$ to $3\ \mu$ (mostly about $1\ \mu$) long. Zygomorphic hyphae often about 50 to $80\ \mu$ long, proximally sometimes branched and measuring about 2 in width, distally widening to about $4\ \mu$ and winding about one another in pairs 2 to 4 times, each of a pair originating from a separate thallus. Zygosporangium sessile on the conjugating filament providing the forefront of the spiral, 10 to $15\ \mu$ in diameter, nearly colorless or faintly yellowish, its wall ornamented with 20 to 30 warty protuberances $.8$ to $1.5\ \mu$ high and 1.5 to $2\ \mu$ wide.

Occurring as a destructive parasite of *Amoeba terricola* (in a more restricted sense) in partly buried decaying leaves of *Lycopersicon esculentum* near Beltsville, Md.

ZOOPAGE TRYPHERA

A member of the Zoopagaceae subsisting on testaceous rhizopods appeared in several old maize meal agar plate cultures to which had been added a few pinches of leaf mold collected in deciduous woods near Butternut, Wis., late in July 1935. Mixed with other forms of microscopic life, *Geococcus vulgaris* Francé (4) had become rather uniformly, even if somewhat sparingly, distributed on the surface of the agar substratum. Marked concentration of these animals, often in conspicuous linear arrangement and always in restricted areas bordering on one or another of the deposits of leaf mold, revealed the extension of predacious mycelia from the decaying rubbish. As conidial apparatus of the *Fusarium*-like hyphomycete I described earlier (3) under the binomial *Dactylella passalopaga* was nowhere to be seen, a closer examination was made, which brought to light, instead, a delicate species of *Zoopage* much more commonplace in its predacious habit.

Capture was effected manifestly through mere adhesion of the animals on the narrow mycelial filaments (FIG. 5, A; B, a-f; C, a).

If, as may be presumed, yellow adhesive material similar to that produced by related fungi was operative here, its recognition was rendered difficult in the presence of a yellowish plug, often of considerable bulk, in the mouth of each captive, where it had been secreted apparently in an effort to resist invasion. In each instance, nevertheless, a very delicate branch from the axial hypha traversed the plug, and after growing a short distance into the interior of the animal, widened and branched dichotomously a number of times to give rise to a well differentiated haustorium through which the protoplasmic contents were gradually appropriated.

Asexual reproduction of the fungus (FIG. 5, C, b; D, a-d) was rather scanty owing probably in part to the meager supply of *Geococcus vulgaris* available in the cultures. In dry mounts the conidia (FIG. 5, E) could be seen to be covered with minute warts, which, however, for the most part became invisible in moist preparations. As in some other catenulate members of the family, the 2 or 3 proximal conidia in the better developed chains were usually longer, narrower, and less regularly sculptured than those borne in more distal positions.

Because of its relatively small dimensions and a generally frail appearance throughout, the species may be aptly described under a name meaning "delicate."

Zoopage tryphera sp. nov.

Mycelium ramosum, sparsum; hyphis hyalinis, .7-1.3 μ crassis; haustoriis pedicellatis, pedicello 2-7 μ longo, .5-.7 μ crasso, saepe sursum incrassato, aliquot ramulos repetite dichotomos .8-2.5 μ crassos sursum attenuatos ferente. Conidia minute verrucosa, elongato-fusoidea, 6-22 μ longa, 1.2-2.2 μ crassa, in catenulis plus minusve erectis ex apice sterigmatum brevium sed saepe ramosorum oriunda, in quaque catenula saepius quina usque quina dena. Zygosporae ignotae.

Geococcum vulgare capiens et consumens, habitat in humo silvarum prope Butternut, Wisconsin.

Mycelium branched, sparse; hyphae hyaline, .7 to 1.3 μ wide; haustoria pedicellate, the pedicel mostly 2 to 7 μ long and .5 to .7 μ wide, often broadening markedly before bifurcating into branches up to 2.5 μ wide, which in turn bifurcate once, twice or three times, usually with progressive attenuation of the elements successively formed to a width of .8 to 1.3 μ at the tips. Conidia very minutely

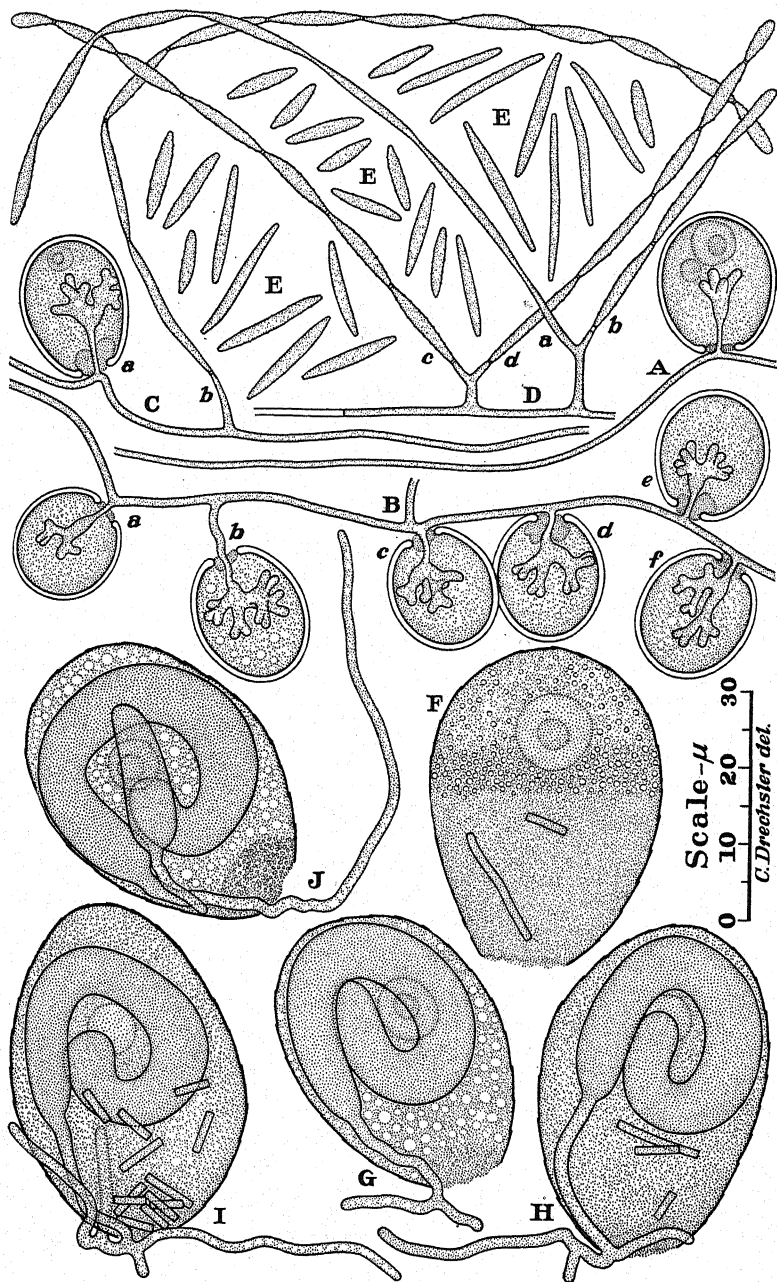


FIG. 5. A-E, *Zoopage tryphera*; F-J, *Cochlonema cylindricum*.

warted, mostly elongated spindle-shaped, 6 to $22\ \mu$ (average $13\ \mu$) in length, 1.2 to $2.2\ \mu$ (average $1.7\ \mu$) in width, produced in numbers usually from 5 to 15 in more or less erect chains arising from short yet sometimes branched sterigmata. Zygospores unknown.

Occurring in leaf mold, capturing and consuming *Geococcus vulgaris*, near Butternut, Wis.

COCHLONEMA CYLINDRICUM

A morphologically very distinctive species of *Cochlonema* made its appearance several times in aging maize meal agar plate cultures originally planted with largish pieces of decaying stem and root tissue cut from tomato plants found wilting in the greenhouse early in December 1935, evidently as the result of root-rot and foot-rot injury. The fungus in question subsisted parasitically on a testaceous rhizopod of the genus *Euglypha*. A somewhat more regularly ovoid contour, and aperture scales neither thickened nor incurved at their tips, readily distinguished the host animal from the congeneric *E. laevis* Perty, cited earlier (3) as prey of *Dactylella passalopaga*. In the dimensions of its glabrous test and of its scales, as well as in the size and position of its nucleus, the rhizopod corresponded well to the description of *E. denticulata* Brown as given by Wailes (5), and is therefore referred to that species. It first attracted my attention by feeding on the oöspores of *Pythium ultimum* Trow scattered abundantly through the agar substratum; in each case applying its mouth to the oöspore wall, digesting a hole through the wall in the area thus circumscribed, and then drawing out the degenerating granular contents, as if by suction. Unlike *Geococcus vulgaris*, which attacks oöspores in precisely the same manner, the animal multiplied rather slowly, its numbers in any of the 4-inch Petri dishes probably not exceeding 100 after a period of 35 days, when destruction by the parasite first became noticeable. Complete extermination followed in less than a week.

Infection of the individual rhizopod results when a conidium of the fungus is ingested (FIG. 5, F) that on germination gives rise to a thick spiral thallus (FIG. 5, G-J) very similar to the thalli of *Cochlonema verrucosum* and *C. dolichosporum*. After the animal's contents have been partly assimilated, the empty spore

membrane frequently becomes visible as a cylindrical appendage attached endwise to the thallus (FIG. 6, *A-C*) indicating that in this species germination is approximately terminal rather than lateral. Attachment, moreover, is at the end of the swollen filament that occupies not the central but the more outward position in the spiral; the cochleate shape here manifestly coming about through introversion of the growing distal portion, rather than through circumvolution as in congeneric forms. This departure from the habit of growth usual in the genus is, perhaps, to be related to the presence of the enveloping rounded test, and to freedom from the continuous indiscriminate rolling entailed in the movement of pelliculate *Amoebae*. Frequently two thalli develop in an infected animal (FIG. 5, *J*; 6, *A*), and even three have been observed in a few instances. Though additional conidia are often ingested (FIG. 5, *H, I*), these for some reason fail to germinate, long remaining visible in the protoplasm of the rhizopod without undergoing any evident change.

Asexual reproduction of the fungus begins usually before the conclusion of vegetative development, being initiated apparently as soon as the host animal has become too feeble to move about, though generally a considerable portion of its substance may still await appropriation. A narrow hypha arising from the older extremity of the thallus makes its way to the mouth of the rhizopod, from which it emerges often with some branching and an abrupt change in direction (FIG. 5, *G-J*). Penetration into the substratum is usually not extensive, all later growth being in most instances wholly aerial (FIG. 6, *A*). In places where several infected animals have been halted fairly close together, the filaments proceeding from them often become more or less entangled with one another in rangy curling loops, to provide a woolly display much more profuse than might be expected from the volume of the subjacent thalli. As each of the filaments attains definitive length it becomes converted into a chain of sharply truncate cylindrical spores (FIG. 6, *B-E*). A second filament may grow out from below the proximal member of the chain to give rise to a second conidial chain. Through repetition of such development, additional chains are produced until the progressive evacuation of the underlying thallus has been completed, leaving only a num-

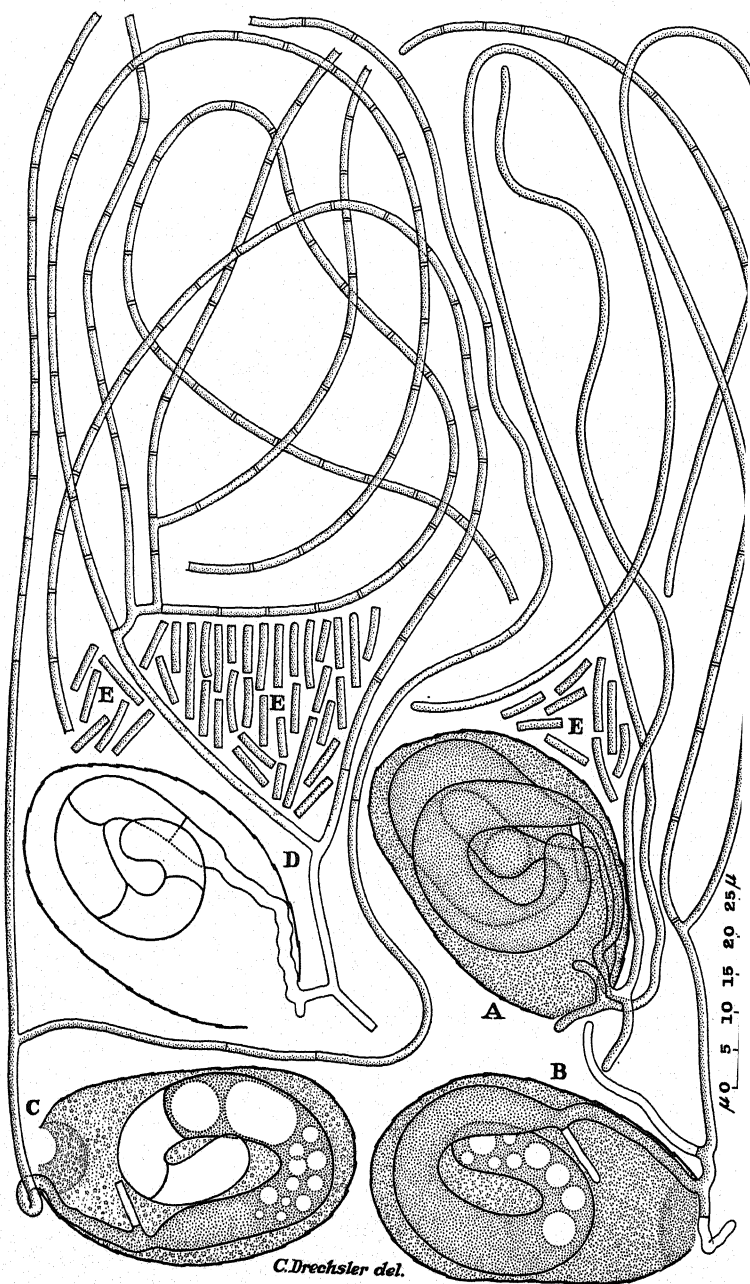


FIG. 6. *Cochlonema cylindricum*.

ber of successive cross-wall in the empty cochleate envelope (FIG. 6, D).

Cochlonema cylindricum sp. nov.

Hyphae alitae 5–8.5 diam., simplices, semel vel bis introrsum spiraliter convolutae. Conidia hyalina, cylindracea, utrimque abrupte truncata, recta vel leniter curva, 4–17 μ longa, 1.1–1.3 μ crassa, in catenulas longas, simplices vel basi paulo ramosas, flexuosas, saepe inter se aliquanto intricatas connexa. Zygosporae ignotae.

Euglypham denticulatam enecans habitat in radicibus putrescentibus *Lycopersici esculenti* prope Beltsville, Maryland.

Vegetative hyphae mostly 5 to 8.5 μ in diameter, spirally convoluted in a circinate coil of 1 to 2 turns. Conidia hyaline, cylindrical, abruptly truncate at both ends, straight or slightly curved, 4 to 17 μ , mostly 5 to 10 μ . (average 7.2 μ) long and 1.1 to 1.3 μ wide; produced in large numbers in long, flexuous, simple or basally branched, sometimes distally intertwined chains, wherein they are separated by evacuated but not constricted portions of filament mostly about .3 μ long. Zygosporae unknown.

Parasitic on *Euglypha denticulata* and occurring in decaying roots of *Lycopersicon esculentum* near Beltsville, Md.

BUREAU OF PLANT INDUSTRY,
U. S. HORTICULTURAL FIELD STATION,
BELTSVILLE, MARYLAND

LITERATURE CITED

1. Drechsler, C. Some conidial Phycomycetes destructive to terricolous *Amoebae*. *Mycologia* 27: 6–40. 1935.
2. —. New conidial Phycomycetes destructive to terricolous *Amoebae*. *Mycologia* 28: 363–389. 1936.
3. —. A *Fusarium*-like species of *Dactylella* capturing and consuming testaceous rhizopods. *Jour. Wash. Acad. Sci.* 26: 397–404. 1936.
4. Francé, R. H. *Das Edaphon*. 99 p. Munich, 1913.
5. Wailes, G. H. *Rhizopoda*, Part III. In Cash, J., & Wailes, C. H. *The British freshwater Rhizopoda and Heliozoa* 3. London, 1915.

EXPLANATION OF FIGURES

Fig. 1. *Cochlonema odontosperma*; drawn with the aid of a camera lucida at a uniform magnification; $\times 1000$ throughout. A, A small susceptible *Amoeba* being infected by a germinating conidium; close to the contractile vacuole is shown a body believed to be the host nucleus. B, A twice bifurcate thallus that has attained its rather unusually large dimensions by de-

veloping alone in an animal of good size; from the outer profile of its older portion have been produced five young conidiiferous filaments. *C*, Three small thalli putting forth from the relatively small animal in which they have developed, one, two and three conidiiferous filaments respectively. *D*, Two thalli, each once bifurcate, which have nearly depleted their host; one of the thalli putting forth six conidiiferous filaments. *E*, Four simple thalli whose contents have been largely used up in asexual reproduction, the resulting conidial chains not being shown from lack of space. *F*, A simple thallus partly depleted of contents in asexual reproduction, one of the shorter conidial chains being shown in sections; *a* and *b* representing corresponding points in these sections. *G*, A random assortment of conidia. *H*, An assortment of conidia, including mostly branched, filamentous, and relatively large specimens.

Fig. 2. *Cochlonema odontosperma*; drawn with the aid of a camera lucida at a uniform magnification; $\times 1000$ throughout. *A*, Sexual hyphae from two thalli in an exhausted animal, three pairs, *a*, *b* and *c*, having conjugated to form each a young zygosporangium; *d*, a somewhat unusual triple union; *e*, *f*, *g*, zygomorphic hyphae that have failed to make contact with a free mate. *B*, Two thalli that have given rise to four pairs of sexual hyphae, *a-d*; each pair having produced a fully grown zygosporangium showing an early stage in the formation of protuberances. *C*, Three thalli from which have come a pair of young sexual hyphae distally in contact with one another, *a*; three pairs of older sexual hyphae, *b*, *c*, *d*, that have each produced a zygosporangium with fully grown protuberances; and a young unmated sexual hypha, *e*. *D*, Four mature zygosporangia, *a-d*, together with the empty sexual hyphae, the evacuated vegetative thalli and the collapsed pellicle. *E*, Mature zygosporangia, *a-f*, showing variation in size and sculpturing.

Fig. 3. *Cochlonema megaspirema*. *A*, Specimen of *Amoeba terricola* in active movement, though infected with four young vegetative thalli, *a-d*; *n*, nucleus; *v*, contractile vacuole; drawn with aid of camera lucida, $\times 1000$. *B*, A well developed vegetative thallus with the proximal portions of 10 conidiiferous filaments thrust through the substantial pellicle of a depleted large specimen of *A. terricola*; drawn with aid of camera lucida, $\times 1000$. *C*, Sketch showing radial arrangement of conidiiferous filaments about the underlying thallus. *D*, Sketch showing course of conidiiferous filaments through substratum and recumbent posture of aerial prolongations.

Fig. 4. *Cochlonema megaspirema*; drawn with the aid of a camera lucida at a uniform magnification; $\times 1000$. *A*, Three relatively small thalli within the pellicle of a wholly depleted specimen of *Amoeba terricola*. *B*, Conidiiferous filament drawn in sections, the contiguity of which is indicated by the letters *a-k*; *a-c*, submerged proximal portion; *c-d*, little differentiated proximal portion of aerial prolongation; *d-h-k*, chain of spores resulting from conversion of the well differentiated distal portion of the filament as at first produced; *e-g*, differentiated branch growing from below the basal member of the mature conidial chain. *C*, A random assortment of conidia, *a-g*, showing variation in size and shape. *D*, Portions of three thalli with four pairs of distally interinvolved sexual hyphae that have produced four fully grown zygosporangia, *a-d*, respectively. *E*, *F*, Zygosporangia with mature zygosporangia, considered as probably belonging to the fungus.

Fig. 5. Drawn with the aid of a camera lucida at a uniform magnification; $\times 1000$ throughout.

A-E, *Zoopage tryphera*: A, Portion of hypha with an incompletely developed haustorium inside of a captured specimen of *Geococcus vulgaris*. B, Portion of hypha with six captured specimens of *G. vulgaris*, a-e, each of which, with the exception possibly of a, reveals a fully developed haustorium in its interior. C, Portion of hypha showing a fully developed haustorium in the captured specimen of *G. vulgaris*, a; and also a chain of conidia on the sterigma, b. D, Portion of hypha with two branched sterigmata: one bearing an immature sporogenous filament, a, in addition to the mature conidial chain, b; the other bearing two mature conidial chains, c and d. E, Conidia, showing variation in size and shape.

F-J, *Cochlonema cylindricum*: F, Two conidia shortly after ingestion by a specimen of *Euglypha denticulata*. G-I, Specimens of *E. denticulata* each containing a single thallus, which has established contact with the substratum by means of a slightly branched filamentous outgrowth; in H and I are shown also inside of the animal some ingested conidia that betray no sign of germination. J, Specimen of *E. denticulata* with two thalli, the larger having thrust a hyphal outgrowth through the mouth of the host.

Fig. 6. *Cochlonema cylindricum*; drawn with the aid of a camera lucida at a uniform magnification; $\times 1000$. A, Specimen of *Euglypha denticulata* containing two thalli, each of which has produced a growing aerial filament. B, Specimen of *E. denticulata* containing a thallus that after giving rise to a chain of conidia is supplying material for the continued elongation of a sporogenous branch proliferated from below the proximal member of the chain. C, Specimen of *E. denticulata* containing a thallus that has become partly evacuated in the production of two long conidial chains; these chains being shown only in part from lack of space. D, Specimen of *E. denticulata* reduced to an empty test in supplying nourishment to a thallus that now is represented only by an empty membrane; four septa were laid down in the membrane during the progressive evacuation that resulted in six long conidial chains shown only in small part from lack of space. E, Conidia, showing variation in size and shape.

NEW SPECIES OF HYPHOMYCETES

DAVID R. SUMSTINE

Rhinotrichum Noblesiae sp. nov.

Stratum very thin, effused, floccose to definite crust-like layer, brownish-yellow, raw sienna-antique brown in Ridgeway's Color Standards and Nomenclature, with white patches and streaks scattered over the surface; hyphae hyaline, septate, branched; sporophores long, branched, septate, attenuate upwards, with upper division bearing spicules; spores ovoid to ellipsoid, hyaline to yellow by transmitted light, with granular contents, variable in size, median size $10-12 \times 14-16 \mu$.

On coniferous boards, Arctic Ice House, Winnipeg, Manitoba, September 5, 1935.

This species resembles *Rhinotrichum tenerum* Sumstine. It may be separated from that species by the difference in color, shape and size of the spores, and the lack of H-shaped formations in the hyphae.

The specimens were contributed by Dr. Irene Mounce and Dr. M. K. Nobles of the Dominion Experimental Farm, Ottawa, Canada.

Part of the original collection is deposited in the herbarium of the Carnegie Museum, Pittsburgh, and part in the herbarium of the Dominion Experimental Farm.

Streptothrix Mounceae sp. nov.

Fructification composed of small tufts, 1 mm. or less across, sometimes confluent, brown, near raw umber in Ridgeway's Color Standards and Nomenclature; mycelium hyaline, branched 2μ in diameter; sporophores erect, repeatedly branched, branches short or at times long, tortuous (corkscrew); spores borne at end of the branches singly or doubly, hyaline at first, then brown colored, ovoid to ellipsoid, one-guttulate, $4-5 \times 6-8 \mu$.

On bark of dead twig, Kenora, Ontario, September 25, 1932.

This species is related to *Streptothrix fusca* Corda. It differs from that species in color and in smaller one-guttulate spores.

The specimen was collected by G. R. Bisby and communicated by Dr. Irene Mounce and Dr. M. K. Nobles, of the Dominion Experimental Farm, Ottawa, Canada.

Part of the original collection is deposited in the herbarium of the Carnegie Museum, Pittsburgh, and part in the herbarium of the Dominion Experimental Farm, Ottawa, Canada.

CARNEGIE MUSEUM,
PITTSBURGH, PA.

LIME-LOVING MOLDS FROM AUSTRALIAN SANDS

CHARLES L. PORTER AND GEORGE ZEBROWSKI

(WITH 1 FIGURE)

The organisms described in this paper were discovered by Mr. Zebrowski while making an examination of sand obtained from Ward's Natural Science Establishment of Rochester, New York. Since this first discovery, various lots of calcareous sands have been placed at our disposal by Dr. J. D. Corrington and Dr. F. H. Ward, both officials of the Ward Establishment. The authors take this opportunity to thank these men for their generous co-operation. These organisms have been found in sands collected from Australia, China, Africa, Texas, North Carolina and the West Indies. They apparently have a world-wide distribution.

The most striking peculiarity concerning these organisms is the fact that they are not indicated merely by their imprints on the surfaces of shells, but they actually penetrate the calcareous substance, producing in many cases an abundant, tangled network of hyphae among which are numerous sporangia, frequently containing spores. This lime-loving trait seems to be common to all forms here listed. Most of these forms were found on fragments of molluscan shells, although they were also encountered on shells of *Foraminifera*, *Ostracoda*, and even within the spicules of calcareous sponges. As such habitats might suggest all the forms were microscopic. Sands bearing these organisms were also rich in the remains of *Foraminifera*, *Ostracoda*, fish bones and scales, and sponge spicules. Representative genera of *Foraminifera* included species of *Lagena*, *Globigerina*, *Spiroloculina*, *Textularia* and *Nodosaria*. Since these species range from the Cambrian to the present, the organisms here described as associated with them may or may not be existing at the present time. Remarkably well preserved specimens which are quite common in the sands argue for a recent origin. On the other hand, the fact

that they are embedded in a calcareous matrix may account sufficiently for the excellent state of preservation.

Most of the specimens which are the subject of this paper were exhibited at the 1934 meeting of the Mycological Society at Pittsburgh. Many suggestions were made as to the probable nature of these organisms. It was suggested that algae, tests of *Protozoa* or the holdfasts of *Bryozoa* might be included among the specimens shown. All these suggestions have been carefully considered and a critical reexamination has been made of all the specimens in our collection. Comparisons were made with various incrustations that may be found on molluscan shells, with egg cases of leeches, with cysts of *Cercariae* of fresh-water snails, with tests of several protozoa (*Radiolaria*, *Heliozoa*, *Lobosia*, etc.). No specimens were found in these inquiries that could be compared to the organisms here described. In our investigation we have excluded all forms occurring on the surface of shells and have considered only those actually imbedded in the shell. The writers were unable to find any described species of protozoa or other invertebrates which could or do produce microscopic tunnels in the hard lime layers of the shells, spicules, etc., which were found.

The large number of specimens discovered in some of the species, where the characteristics were always constant, preclude, in these forms at least, the possibility that our descriptions are based on artifacts, cracks or checks in the shells, or upon other errors in observation. Although we have a large number of described forms there are many others which were omitted either because they were generalized forms upon which no description could be based or because they might be the remains of some of the invertebrates above mentioned. There are, of course, no absolute criteria by which we can state definitely that some of the described species are not primitive algae rather than molds. There seems to be some evidence that we have here some border-line groups which partake of both fungal and algal characteristics. There are also specimens which suggest that these lower fungi may have myxomycetous origin, as transitional forms showing traits common to both were frequently encountered. It is hoped to discuss these interesting relationships in a forthcoming paper.

The unusual preservation and clarity of details makes it possible to work out the life-histories of a number of species of these fungi. A structure, common to most forms, is the presence of



FIG. 1.

pear-shaped or globular sporangia imbedded in the shell substance and opening to the exterior by excretory pores. Usually there is a single pore but in some species there may be several. In many of the species the sporangia are multiple; that is, lateral pouches

or outgrowths arise from the primary sporangium. It is in these, rather than in the primary sporangia, that spores seem to be produced. In some forms the lateral sporangia are produced in linear series presenting somewhat the appearance of a row of gourds with long necks, arranged end to end. In other forms the secondary sporangia are so arranged that the entire sporangial complex resembles the fingers of a hand, or the rays of a star. In a thick shell the lateral sporangia may be symmetrically arranged in the form of star rays. When the shell is very thin, the primary and secondary sporangia may all lie in a single plane simulating a hand with outstretched fingers. Distributive hyphae are also characteristic of most of these molds. These hyphae arise from the walls of either the primary or secondary sporangia and are variable in thickness, but fairly constant for a given species. Usually they are single and unbranched and ramify through the shell for long distances. Eventually at their ends, or subterminal in position, young sporangia are produced which upon developing to maturity produce in turn lateral sporangia and new distributive hyphae. In this manner these molds form a colony of intermixed hyphae which grow from a sporangium. There are frequently other shorter hyphae which are apparently vegetative in nature. In a few forms these nutritive hyphae are arranged in a radial manner at the surface of the shell, the sporangial opening being approximately in the center. In most cases, however, these hyphae as the former, are imbedded within the shell substance and present a rhizoidal appearance. In some species distributive hyphae were observed to terminate in a pair of comma-shaped bifurcations, one of which was larger than the other. These occurred where normally sacs were found on other hyphae and may have sexual significance.

A few forms in which hyphae are entirely lacking resemble a plasmodium with numerous processes and is covered with spines, hairs, or denticles. In such forms the entire thallus apparently functions as a single or multiple sporangium.

The multiple sporangial forms abstrict portions of the protoplasm in the lateral processes, in which the entire protoplasm undergoes transformation into spores. Usually, also, such abstricted portions of the thallus develop their own excretory pores

by which the spores are discharged. As these spores ripen, other areas of the thallus are abstricted, thus gradually transforming the protoplasm of the entire thallus into spores. Usually the apertures are about the size of the spores. However, in some cases the apertures are much smaller than the spores contained within the sporangium, which would suggest that the spores would have to be amoeboid to squeeze their way through. In these latter instances the spores are irregular in outline suggesting strongly amoeboid tendencies. Where, however, the spores are walled and possess regular outlines, the excretory apertures approximate them in size. In color, the spores are usually some shade of yellow or brown, when mature.

It was found possible to isolate hyphae and spores from the matrix by the dissolving action of hydrochloric acid. In some of the coarse specimens so treated, spore-developing areas could frequently be observed along the course of single hypha. The more developed of these areas were apparently cut off from the remaining hyphae by septa. An aggregation of these spores, varying from few to many, would lie surrounded on all sides by an undifferentiated brittle matrix, which crumbled when touched. These spores were of the same greenish color as the remainder of the thallus and did not possess the definite shape or pigmentation of those fully matured. On many of the pieces of shell there adhered numerous red or brown spores which were dislodged with difficulty. Frequently they were also imbedded in depressions which they seem to have dissolved for themselves. In some forms, spores had to be picked out with needles. These multiple spores adhered together in clumps, and were separated with difficulty. These observations would indicate that mature spores are covered with a cementing substance which cause them to adhere to each other and to the surface of other objects.

The molds were isolated from various samples of sand by examining small quantities in Petri dish in xylol. This reagent cleared the specimens promptly and, following the clearing process, they could readily be "picked out" under a binocular microscope. The xylol evaporated completely from the sand and did not alter it in any way. The fragments of shells showing molds were re-

moved from the xylol with a curved, flattened needle and were mounted directly into balsam.

Many pieces of shell were so curved that it was practically impossible to get the entire specimen in the same optical plane. Photography was obviously unsatisfactory in making such records. Where difficulties of this kind were encountered sketches were added to complete the illustrated records of this collection.

The photographs illustrating this article were prepared by Dr. Edwin J. Kohl of Purdue. The photographs were made directly from balsam mounts. The writers wish to acknowledge their indebtedness to Dr. Kohl for his fine contribution to this investigation.

The writers are of the opinion that an unusual habitat for molds has been discovered and that new species may be found by examining calcareous sands from different parts of the world. The better preserved deposits of marl theoretically should offer unusual facilities for conducting these studies.

It is believed that most of the forms that have been examined are Phycomycetous fungi, a few being allied with the Cladochytriaceae. Some may be more closely related to the Myxomycetes.

PURDUE UNIVERSITY,
LAFAYETTE, IND.

EXPLANATION OF FIGURE

Fig. 1. *A*, central sporangium with lateral pouches arranged palmately; *B*, numerous sporangia with ostioles; distributive hyphae originating near the ostiolar openings; *C*, an arborescent species on a shell fragment; *D*, dense population of shell fungi; sporangia and distributive hyphae shown; *E*, thallus, probably a sporangium, with lateral pouches; distributive hyphae arising from the lateral pouches; in shell matrix; *F*, branched thallus form with sporangium opening at the shell surface; note distributive hyphae; *G*, large paramoecium-like form; no lateral pouches; hyphae branch at right angles; note ostiole at the apex of the figure; *H*, simple sporangia united by distributive hyphae; *I*, spiny shell fungus; *J*, shell fungi in a sponge spicule.

ADDITIONAL DATA ON SEX REACTIONS IN MONOSPORE RACES OF NEURO- SPORA TETRASPERMA¹

BERNICE SEAVER

(WITH 7 FIGURES)

In *Neurospora sitophila*, which is obligately heterothallic, after the fusing nuclei come together in the ascus or spore mother cell, the nuclear spindles are commonly oriented in such a way as to insure the cutting out of eight uninucleate spores. If the factors for sex segregate at the first division, the eight spores in the ascus will be arranged so that the four spores in one end of the ascus will be of one sex and the other four of the opposite sex (Dodge, 1927). If the factors for sex segregate at the second division, the spores will be arranged in the ascus with two sexes alternating, two spores of one sex and two spores of the other, etc. (Wilcox, 1928). The spindles, during the second division in *N. sitophila*, lie one directly above the other and longitudinally in the ascus.

In the species *N. tetrasperma*, they more frequently lie at an angle and parallel to each other (Colson, 1934) but not infrequently (Dodge, 1927) they appear to lie one above the other, as in *N. sitophila*, although this may sometimes be due to the particular plane in which the ascus was cut in sectioning. This orientation of the spindles in *N. tetrasperma* is such that the spores to be cut out later will have two nuclei instead of one at their origin and, usually these nuclei will be opposite in their sex reactions.

Dodge has assumed that when the spindles lie one above the other in *N. tetrasperma* and segregation of the sex factors occurs at the first division there is something corresponding to a sex attraction strong enough to cause a rearrangement of the four resulting nuclei before the third division takes place. This attrac-

¹ Paper read at a meeting of the Mycological Society of America at Atlantic City, December 30, 1936.

tion would tend to move one nucleus of the upper spindle downward and the one nucleus of the lower spindle upward so that the four nuclei would finally lie two of opposite sex in each end of the ascus, or, in the same position taken by the nuclei following the conjugate type of orientation. In a recent paper Dodge (1936) shows how bisexual spores might be cut out without any rearrangement when the sex factors segregate in the second division. He shows also in the same paper how binucleate unisexual spores might be cut out by having the spindles oriented in the same manner, one above the other, but with the sexes segregating at the first division. These are purely hypothetical possibilities. We need further cytological evidence on this point.

Both Dodge and Lindegren have reported finding large unisexual spores. Dodge (1928) states, "Single ascospore cultures were made by germinating what were judged to be normal homothallic spores of *Neurospora tetrasperma*. Of some fifty such cultures only one failed to produce perithecia and it was discarded." Lindegren (1932), in germinating spores taken from 5-spored asci, found but one ascus out of thirteen which contained three binucleate unisexual spores and two uninucleate spores. Two of the binucleate spores were of one sex and the other binucleate spore and the two uninucleate spores were of the other sex. However, it was assumed that the per cent of these spores was very small, possibly two per cent, but this conclusion was based on very little evidence. At Dr. Dodge's suggestion I undertook to obtain further data.

Ascospores from a 4-spored ascus commonly measure about $31 \times 15 \mu$. Uninucleate spores from asci containing more than four spores measure about $22 \times 12 \mu$. My object was to test a larger number of the normal sized spores. The spores were taken from a spore print with a platinum loop and spread on a petri dish of corn meal agar. They were allowed to stand for several hours in order to give the conidia which might have been included accidentally a chance to germinate. Then they were heated for an hour at 55°C . This heating process kills the conidia which have started to germinate and also stimulates the germination of the ascospores. About six hours after they have been heated the spores germinate enough so that they may be cut out

on blocks of agar and removed to tubes of cornmeal agar. As far as possible the normal sized spores were chosen avoiding the small uninucleate ones.

About 1400 spores in all were isolated.² Two sets of spores were analyzed. The first were spores from matings of two normal races. The other set were the products of matings of a normal race with a lethal race, the lethal being one that carries a recessive lethal factor, *l*, which when homozygous, or *ll*, in an ascus causes ascus abortion without spore formation. When the ascus is heterozygous, or *Ll*, ascospores are cut out normally. It is impossible to tell the difference by looking at the spores in an ascus, between those from the mother ascus which was homozygous, *LL*, and those from an ascus which was heterozygous, *Ll*, because *L* is dominant and therefore both kinds delimit spores and are otherwise normal in their appearance.

About ten per cent of these normal sized spores (both races included) proved to be unisexual in their reactions. Of spores from the normal, $S_1 \times S_0$, there were 500 isolated and 49 of these were unisexual spores (TABLE 1). Ten of these unisexual spores were of sex *A* and 39 of sex *a*. In the normal plus lethal race there were about 400 spores isolated and 51 of these spores (TABLE 2) were unisexual in their reactions, 30 of sex *a* and 21 of sex *A*, 22 lethal (homokaryotic) and 29 normal, either homokaryotic *L* and *L* or heterokaryotic *L* and *l*.

TABLE 1
SPORES TESTING AS UNISEXUAL BUT LARGE ENOUGH TO HAVE ORIGINALLY
CONTAINED TWO NUCLEI (SPORES FROM MATINGS OF
TWO NORMAL STRAINS, $S_1 \times S_0$).

| No. | Size | Sex A | Sex a |
|-----|-----------------------|-------|-------|
| 3 | $28 \times 15-18 \mu$ | 1 | 2 |
| 1 | $30 \times 17 \mu$ | 1 | |
| 29 | $31 \times 15-18 \mu$ | 5 | 24 |
| 2 | $32 \times 15-18 \mu$ | 1 | 1 |
| 5 | $33 \times 15-18 \mu$ | 1 | 4 |
| 3 | $34 \times 15-18 \mu$ | | 3 |
| 2 | $35 \times 15-18 \mu$ | | 2 |
| 4 | $37 \times 15 \mu$ | 1 | 3 |
| 49 | | 10 | 39 |

² Of these 500 were not considered in the computation because the unisexual spores among this number were not measured. The percentage would not have been changed materially if they had been included.

TABLE 2

SPORES TESTING AS UNISEXUAL BUT LARGE ENOUGH TO HAVE ORIGINALLY CONTAINED TWO NUCLEI (SPORES FROM HETEROZYGOUS ASCI FROM A MATING OF A NORMAL *L* STRAIN, S_9 , AND A LETHAL *l* STRAIN, 9.7 C_8).

| No. | Size | Lethal | | Normal | |
|-----|-----------------------|--------------|--------------|--------------|--------------|
| | | Sex <i>a</i> | Sex <i>A</i> | Sex <i>a</i> | Sex <i>A</i> |
| 2 | $28 \times 18 \mu$ | | | 1 | 1 |
| 2 | $30 \times 16-20 \mu$ | 1 | | 1 | |
| 36 | $31 \times 15-18 \mu$ | 10 | 7 | 12 | 7 |
| 3 | $32 \times 15-17 \mu$ | 2 | | | 1 |
| 4 | $33 \times 15-18 \mu$ | | | 2 | 2 |
| 2 | $35 \times 17-18 \mu$ | | 1 | 1 | |
| 2 | $37 \times 15 \mu$ | | 1 | | 1 |
| 51 | | 13 | 9 | 17 | 12 |

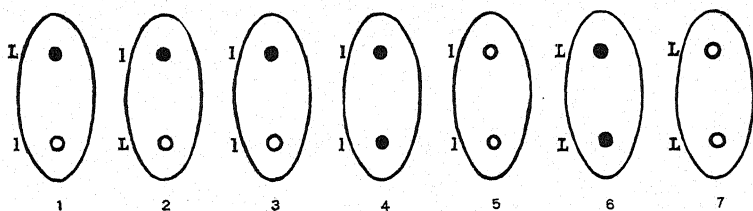
Whether these unisexual spores referred to above actually contain two nuclei of the same sex has not yet been proved. There are two striking facts brought out by the results shown in the tables that would seem to indicate that these spores contain only one nucleus:

First. From some 900 bisexual spores from the mating $S_9 \times 9.7 C_8$ tested only one spore (FIG. 3) proved to be homokaryotic for the lethal. Of the 49 unisexual spores tested about half of them were homokaryotic for the lethal (FIG. 4, 5) with the sexes about equally represented. That both nuclei should carry the lethal factor is a point not easily understood if there were actually two nuclei in each spore at its origin. That is, binucleate unisexual spores, homokaryotic for the lethal *l* should be no more numerous proportionately than the bisexual spores that are homokaryotic for the lethal. As a matter of fact, however, tests have proved that the former were about 1000 times more numerous. There is no evidence that would indicate a linkage between the lethal and sex factors.

Second. In the progeny from the mating $S_1 \times S_9$ there were many more of the unisexual spores testing as sex *a* than as sex *A*. Theoretically the sexes should be more evenly divided.

It is possible that most of these apparently unisexual spores (FIG. 4, 5, 6, 7) were not originally unisexual but at their origin contained two nuclei which were opposite in their sex reactions

and heterokaryotic for the lethal just as those spores illustrated in figures 1 and 2 but one of the original nuclei was killed or injured, possibly in the process of heating the spore for germination or for some other reason, so that these spores finally contained only active nuclei of one sex. These spores would then test as unisexual and homokaryotic for any other factors. That the division of one of the nuclei may be delayed for a considerable period of time in some cases is likely since occasionally a culture will produce a few perithecia after a much longer period of time than is ordinarily the case with bisexual spores. It is known that when the conidia of such fungi as *Neurospora* and *Aspergillus*



FIGS. 1-7. Diagram of seven possible types of ascospores of *Neurospora tetrasperma* with two nuclei at their origins found in single spore isolations, from matings of a lethal race, and a normal race: L, normal factor for spore delimitation; l, lethal factor for ascus abortion; black nuclei, sex A; white nuclei, sex a.

are heated for an hour or two at high temperatures, while they may not be killed, their germination is delayed a long time (Dodge, 1928). Conidia of *Neurospora* ordinarily would germinate in about 4 hours but when given the heat treatment germination may be retarded as much as 3 days. This probably means that the heat treatment affected the nuclei so that the rapidity with which they divided was slowed up. It may be that the heat treatment necessary for germination sometimes, either kills the nuclei of one sex or greatly retards the rate of division. The S_1 and 9.7 C_8 , a races, grow more rapidly and seem to be more vigorous than the S_9 and 9.7 C_4 , A races. It is possible that the A nuclei are more susceptible to injury by heating than the a nuclei. This is a difficult point to prove because so few spores of *N. tetrasperma* will germinate without heating.

Having accumulated additional data regarding the normal sized unisexual spores and their sex reactions, the next problem is to determine, if possible, whether or not these really are binucleate at their origin.

In the case of the spores from the normal, $S_1 \times S_9$, mating, this might be proved by germinating spores taken directly from the ascus. If the two sexes were evenly divided among the four spores of an ascus, two of one sex and two of the other, the chances are that the spores were binucleate. If, however, asci could be found in which the sexes were unevenly divided, *i.e.*, three of one sex and one of the other or all four of the same sex we could definitely say that the spores contained living nuclei of only one sex at the time of their germination.

In the case of the spores from the normal plus lethal mating, $S_9 \times 9.8 C_8$, two methods would have to be used. Sex *a* race produces abundant conidia on potato dextrose agar and since Dodge (1928) has proved that in the case of heterokaryotic spores there should be three kinds of nuclei from bisexual mycelia, and two kinds from unisexual mycelia, the proper method here would be to isolate conidia. If the original spore contained two nuclei, homokaryotic as to sex and heterokaryotic as to the lethal factor, by isolating the small conidia we should get conidia whose mycelia should eventually produce normal 4-spored asci and also those which would produce aborted asci, when mated. There would be more conidia of the normal type, however, since the lethal factor tends to suppress the conidia somewhat. The *A* sex could not be tested by this method since this sex produces very few conidia, lethal or normal. The best way to analyze these spores would be to cut off hyphal tips and grow them. This should produce the same results as the conidia of sex *a*.

SUMMARY

All normal sized spores of *Neurospora tetrasperma* should contain two nuclei of opposite sex reactions at their origin. Actually only 90 per cent of these proved by experiments to be such. The other 10 per cent tested as unisexual. Three possible explanations for this discrepancy are as follows:

1. If the normal sized spores testing as unisexual contain two living nuclei the sex attraction, previously exerted in the ascus, is not strong enough to *always* bring unlike sexes together in one spore (FIG. 4, 5, 6, 7).

2. If there are nuclei of only one sex after the spore germinates the nuclei of the other sex may have been killed in the process of heating the spore to bring about germination (FIG. 1, 2, 3).

3. If there is only one nucleus that functions it may be that the one nucleus failed to divide when the first nucleus did and was thus crowded out and eventually died, i.e. in the processes (nuclear divisions) leading up to spore delimitations it may be, as Campbell (1937) points out for *Gelasinospora tetrasperma*, that one or more of the nuclei failed to divide along with the others and therefore degenerated. This would leave fewer than eight nuclei to be included in the spore complement.

The writer wishes to express her appreciation to Dr. B. O. Dodge, under whose supervision these experiments were conducted.

THE NEW YORK BOTANICAL GARDEN

LITERATURE CITED

- Campbell, Iris. 1937. Further data on monosporous cultures of *Gelasinospora tetrasperma*. Bull. Torrey Club (In press).
- Colson, Barbara. 1934. The cytology and morphology of *Neurospora tetrasperma* [Shear and] Dodge. Ann. Bot. 48: 2-24.
- Dodge, B. O. 1936. Interspecific hybrids involving factors for ascus abortion in *Neurospora*. Am. Jour. Bot. 23: 555-561.
- . 1927. Nuclear phenomena associated with heterothallism and homothallism in the ascomycete *Neurospora*. Jour. Agric. Res. 35: 289-305.
- . 1928. Unisexual conidia from bisexual mycelia. Mycologia 20: 226-234.
- Lindgren, Carl C. 1932. The genetics of *Neurospora*. 1. The inheritance of response to heat-treatment. Bull. Torrey Club 59: 85-102.
- Wilcox, Marguerite S. 1928. The sexuality and arrangement of the spores in the ascus of *Neurospora sitophila*. Mycologia 20: 3-17.

EXPLANATION OF FIGURE

Nos. 1-2. Spores of these types, bisexual and heterokaryotic, *L* and *l*, were actually found.

No. 3. One spore of this type, bisexual and homokaryotic, *l* and *l*, was found. There must have been a spore, bisexual and homokaryotic, *L* and *L*, in the same ascus with spore No. 3, but such a spore was not actually found as proved by tests.

Nos. 4-7. Spores large enough to have contained two nuclei at their origin tested as these figures show, unisexual and homokaryotic, *l* and *l*, and *L* and *L*, but whether these spores actually contained two nuclei as the diagram shows has not yet been proved. This could not be proved in the case of Nos. 6 and 7 without introducing a third factor such as a non-conidial factor. Until it is definitely proved that such spores do not contain two nuclei at their origin or do not contain two living nuclei at the time of their germination we will have to assume because of their size that they were as diagrammed.

NOTES AND BRIEF ARTICLES

THREE THOUSAND MYCOLOGICAL TERMS

The Rhode Island Botanical Club has sponsored a second publication prepared by the undersigned, entitled "Three Thousand Mycological Terms." It is a glossary of terms used in Mycology, descriptive, taxonomic, morphological and cytological. It is small octavo of 151 pages, and 12 plates of line-drawing illustrations prepared by Henry A. C. Jackson. The price is \$2.00 and it may be obtained by forwarding a check to the author.

This glossary has been prepared not for pecuniary profit, but as a small service to English-speaking students of Mycology and Phytopathology. This service can be complete in the future only with the coöperation of other mycologists. Hence, the compiler of this small work will welcome the receipt of new terms and definitions, criticisms of those already included, differences of opinion, and suggestions as to changes of any sort. Only by such coöperation can a future edition be made reasonably complete, up-to-date and adequate.—WALTER H. SNELL.

The unchanged reprint of Elias Magnus Fries, *Hymenomycetes Europaei*, which was published in Svea 1874, has now appeared. The price of the book so important for mycological research is R.M. 45,—. It is edited by Dr. Werner Klinkhardt, Leipzig.

The preparation of the YEARBOOK of the Mycological Society of America will shortly be commenced. Members are urgently requested to send, at their earliest convenience, to the Secretary-Treasurer, 20 Divinity Avenue, Cambridge, Mass., any change in address or other additions or corrections to the subject matter of the YEARBOOK as it appeared last year.

MYCOLOGIA ENDOWMENT FUND

During the past year a rather strenuous campaign has been conducted to sell the early volumes of MYCOLOGIA. This has given surprising results. From the amount accumulated during the latter part of 1935 and 1936 we have added \$2500.00 to our restricted Mycologia Endowment Fund, bringing the total up to \$4500.00. This money is invested by the New York Botanical Garden, and interest prorated to MYCOLOGIA each year. It is hoped that this endowment may be increased each year until it is of sufficient size to yield a substantial income to be expended on current issues of MYCOLOGIA.—F. J. SEAVER.

RELIQUIAE FARLOWIANAE

The eighth century of the Reliquiae Farlowianae was issued on February first. The specimens have been selected either because of their rarity, their historic value, or to add to our knowledge of the geographic distribution or host-range. Among the specimens are eight which represent type collections: *Bifusella crepidiformis* Darter; *Aecidium Pereziae* Arth.; *Peridermium guatemalense* Arth. & Kern; *Pileolaria extensa* Arth.; *Puccinia fidelis* Arth.; *Puccinia Tetramerii* Seymour; *Ravenelia Farlowiana* Diet.; and *Ravenelia versatilis* (Pk.) Diet. As exemplified by specimens from the Thaxter Herbarium, the numbering may seem confusing since in a few instances the numbers follow the names of the person who made the determinations. This method of citation has been adopted because Dr. Thaxter followed no definite system of numbering, but rather gave a new series of numbers to each lot of specimens sent out to specialists. The result is that the same number may be found applied to one or more species in unrelated groups, and some of these numbers have appeared in the literature. Therefore, in addition to the arbitrary numbers mentioned, a regular herbarium accession number has been assigned to each specimen in order to avoid future confusion in citation.

In addition the Reliquiae Farlowianae, the Farlow Herbarium will shortly issue the first fifty numbers of the Reliquiae Tuckermanianae, which like the former will be sent out on an exchange

basis. The specimens are those that Edward Tuckerman had obviously intended to issue in continuation of his *Lichenes Americae Septentrionalis*. Among the material are several type collections which it seems highly desirable to distribute as widely as possible. All of the material has been compared with that in the Tuckerman Herbarium in order to insure the identity of the specimens. Also, to illustrate Tuckerman's concept of the taxonomy of the lichens, each specimen is assigned the same name as was applied in the herbarium, this name then being followed by that accepted by Zahlbruckner in his *Catalogus Lichenum Universalis*. When there were two lots of material on different substrata and from widely separated regions as, for example, Massachusetts and South Carolina, or New Hampshire and California, the two specimens are included in the Reliquiae, not only to show in part Tuckerman's concept of the species, but also to give some information as to the geographic variation and range of the species he recognized. While greater duplication would seem permissible because of the historic value of the specimens, most of which are cited in the *Synopsis of North American Lichens*, this has been avoided and duplicate species from different localities or on different substrata have been set aside, with material that is too scanty for distribution in the Reliquiae, for exchange with those institutions which desire a greater representation of the Tuckerman material and which are willing to exchange material of equal historic or taxonomic value.—D. H. LINDER.

A MYCOLOGICAL PILGRIMAGE

Before the last meeting of the American Association for the Advancement of Science at Atlantic City the writer addressed a letter to Dr. H. M. Fitzpatrick, President of the Mycological Society of America, suggesting a trip to the old J. B. Ellis home at Newfield, New Jersey, as a part of our program, if the weather should permit. The weather proved most favorable, and accordingly an impromptu party was made up on Tuesday afternoon, December 29, 1936, Dr. C. L. Shear acting as guide since he had visited this mecca several years earlier.

The distance from Atlantic City was about thirty-five miles and the party, consisting of three car loads, finally succeeded in locating the old home of this famous mycologist. The writer expected to find this place in a condition of dilapidation, but to his surprise the house both externally and internally was in excellent condition, and occupied by Mr. and Mrs. Wasekanez who have owned the place during the last six years. Years ago Professor L. M. Underwood described this place as a little box-like house. The original house while box-like has been extended by numerous additions in the rear, some of which at least must have been there during Ellis' occupancy.

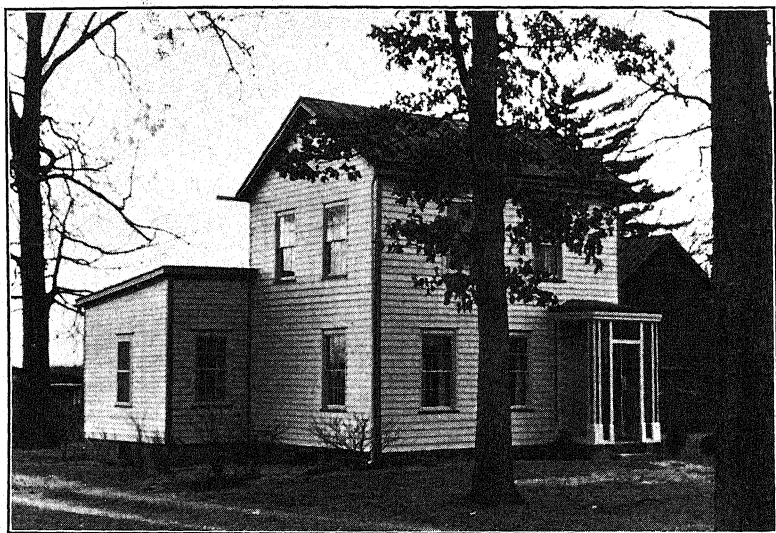


FIG. 1. Front view of the house in which J. B. Ellis lived for the greater part of his life.

It is not surprising that the owner should have regarded this unexpected party with suspicion. These suspicions were soon dispelled, however, when it was explained to him that he was living in a house formerly owned by a famous scientist. After photographs had been taken the lady of the house invited the party in and showed them through the rooms which had formerly housed the Ellis Collection, which later became the nucleus of the mycological herbarium of The New York Botanical Garden.

The writer has in his possession a copy of Ellis' North American Pyrenomycetes, which was purchased directly from Ellis while he



FIG. 2. Side view of the same house showing numerous additions.



FIG. 3. The visiting party. Left to right: H. M. Fitzpatrick, F. J. Seaver, B. O. Dodge, C. L. Shear, G. W. Martin, W. W. Diehl, A. L. Carrion, and C. W. Emmons. This group picture was taken by J. W. Sinden.

was living in this house in Newfield, New Jersey. This copy was purchased in July, 1905, and the letter in Ellis' handwriting is pre-

served in the back of the book. In December of the same year Mr. Ellis died. On at least one other occasion a specimen of a pyrenomycete collected on *Crataegus* while a student in Iowa was sent to Mr. Ellis for determination, the fungus proving to be *Myriangium Duriaei*. This was the extent of the writer's direct communication with Mr. Ellis.

Realizing that all mycologists must have more or less interest in the home and surroundings under which Ellis did his life work, photographs of the house and the visiting party are here reproduced as a matter of historic record. In looking over these surroundings it is surprising that one could have accomplished so much with such meager facilities, and is a striking illustration of what persistence and energy can do.

The photographs accompanying this note were taken by C. W. Emmons and J. W. Sinden.—F. J. SEAVER.

MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOL. XXIX

MAY-JUNE, 1937

No. 3

HYBRIDIZATION STUDIES ON A ZINC- INDUCED VARIANT OF HYPO- MYCES IPOMOEAE

A. W. DIMOCK

(WITH 2 FIGURES)

The first report of variation in fungi attributable to the presence of a toxic chemical substance in the culture medium was that of Archichovskij (1). In his investigation, a series of cultures of a normal, black-spored strain of *Aspergillus niger* was established on Raulin's fluid containing zinc sulfate at a concentration of 0.0001 N which had been found to stimulate growth of this fungus. The spores with which the series was started were obtained from a culture of a single-spore strain of *A. niger* growing on medium containing 0.025 N zinc sulfate, which was near the maximum concentration for growth. A variant strain which bore yellow-brown, rather than black, spores, and which produced a strong reddish-brown pigmentation of the normally colorless culture fluid appeared in the fifth culture-generation of the series. The variant strain retained its characteristics through 24 transfer generations. The appearance of the variant was believed to have been a result of the initial cultivation of the normal strain on the medium containing a sub-lethal concentration of zinc sulfate. In later experiments on induced variation, Brierley (2) was unable to obtain any permanent alteration in either *Aspergillus* or *Penicillium* species, and Tu (7) was unsuccessful in producing variation in *Fusarium* species, by the addition of zinc sulfate or other toxic substances to

[MYCOLOGIA for March-April (29: 151-271) was issued April 1, 1937]

the substrate. Neither of these workers, however, cultivated the fungi on media containing near-lethal concentrations of zinc salts.

The writer (3) has previously described experiments in which quite stable variants of a *Fusarium* species appeared as the result of cultivation of the normal strain on media containing sub-lethal concentrations of zinc salts. The nature of this induced variation, whether cytoplasmic or genetic, could not be determined, for the species involved produced no sexual fruits. Hence, hybridization studies with a zinc-induced variant of *Hypomyces Ipomoeae* have been carried out. This fungus had previously been shown to possess self-sterile strains of opposite sexual reaction which, when mated, readily produced sexual fruits in culture (Dimock, 4). The results of the hybridization investigations are presented in the following pages.

PRODUCTION OF THE ABORTA VARIANT

The experimental procedure employed in the production of the variant may be described briefly. A base medium of the following composition was prepared: sucrose—40 g.; potassium nitrate—8 g.; potassium acid phosphate—5 g.; magnesium sulfate—2.5 g.; agar-agar—60 g.; distilled water to make 1 liter. The molten medium was accurately tubed, 10 c.c. per tube, and sterilized. At the same time, distilled water solutions of zinc nitrate [$\text{Zn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$], containing 0.1%, 0.2%, 0.4%, 0.6%, 0.8%, and 0.9% of zinc (Zn), were prepared, accurately tubed in 10 c.c. lots, and sterilized. Petri plates of zinc-containing media were then prepared by simultaneously pouring the contents of one 10 c.c. lot of base medium and one 10 c.c. lot of zinc nitrate solution into each plate and rotating thoroughly to mix the constituents. This technique was necessary because zinc ion is largely precipitated from solution if the zinc salt is added to the base medium prior to sterilization. Since the volume of the solution was doubled by mixing the constituents, the final concentrations of zinc in the different lots became 0.05%, 0.1%, 0.2%, 0.3%, 0.4%, and 0.45%. It should be pointed out that the actual concentrations of *zinc ion* in the various media were not known. Crystals, presumably of some insoluble zinc salt, were seen to form in the solidified media in a very short time, and to "grow" as the media aged. Concur-

rently, of course, evaporation of water was taking place, so that the zinc ion concentrations may possibly have remained more or less constant. The actual concentrations of zinc ion were of no concern in the present investigation, but it is reasonably certain that they were from the beginning somewhat below the zinc concentrations given above.

Three isolated microsporelings of each of the two tester-strains of *Hypomyces Ipomoeae*, 3-3 (*A*) and 3-14 (*a*) (see Dimock, 4), were planted on each of five plates containing 0.05%, 0.1%, and 0.2% of zinc, and on each of ten plates containing 0.3%, 0.4%, and 0.45% of zinc. Plates of base medium which had been diluted with 10 c.c. of sterile distilled water rather than with zinc solution were similarly planted to serve as checks.

On media containing 0.45%, 0.4%, and 0.3% of zinc, all sporelings save two of 3-3 on a single plate of the last mentioned medium were killed. This was proved by the fact that those which were subsequently transferred to normal malt-extract agar medium failed to grow. Twelve of the fifteen sporelings of 3-3 and fourteen of the fifteen sporelings of 3-14 on medium containing 0.2% of zinc, and all sporelings on media containing 0.1% and 0.05% of zinc, developed colonies.

All colonies save one on medium containing 0.05% of zinc, and all save two on medium containing 0.1% of zinc, were like the *normal* colonies on the check plates except for considerable restriction in growth rate. One 3-14 colony on medium containing 0.05% of zinc was somewhat atypical, and two colonies of 3-3 on medium containing 0.1% of zinc developed sectors. Transfers from these atypical growths to malt-extract agar yielded only *normal* cultures. Colonies on medium containing 0.2% of zinc were greatly restricted in growth, but some eventually developed fast-growing sectors. In spite of repeated transferring from a large number of these sectors, no variant types were obtained.

One colony of 3-14 on medium containing 0.2% of zinc was considerably slower in growth than all the rest, but in other respects was similar to those colonies which failed to develop sectors (FIG. 1). Three transfers to malt-extract agar slopes were made from different points at the margin of this colony. Growth on one of these slopes was of *normal* appearance, while growth on

the other two appeared to be a mixture of *normal* and a variant type of mycelium. The variant component was characterized by more restricted aerial growth and by the production of a bright red diffusible pigment. Repeated sub-culturing was required to obtain a pure culture of the variant. The new strain, designated *aborta*, was proved to be pure and homocaryotic by its constancy through 5 consecutive single-microconidium culture-series consisting of 25 cultures each. All subsequent cultures of this strain have exhibited an unusually high degree of uniformity, having shown no tendency toward "reversion" or further variation.

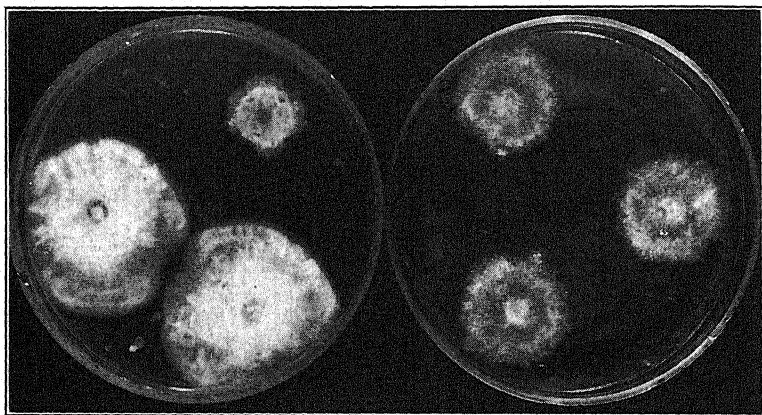


FIG. 1. Petri plates of zinc-containing medium on which the *aborta* strain was produced. The small colony in the plate on the left yielded a mixed culture containing normal and *aborta* components. All colonies originally resembled those in the right-hand plate, but many increased in diameter by more rapid subsequent growth. None save the single small colony shown above yielded a variant, however.

The *aborta* strain differed from *normal* on malt-extract agar by the development of a light, reddish pigmentation of the aerial hyphae and, after 9 or 10 days, of a bright red pigmentation of the medium. On potato-dextrose agar, the aerial hyphae rapidly exhibited a rather beautiful bluish-purple pigmentation, the cultures became strongly fluted, and a deep purple pigment diffused into the medium (FIG. 2). No perithecial fundaments were observed in cultures of this strain on any of the media employed, and it produced conidia much more sparingly than the *normal*.

HYBRIDIZATION STUDIES

The *aborta* strain was mated with both of the *normal* tester-strains (3-3, *A* and 3-14, *a*) in order to determine whether or not it were fertile, whether or not the sexual-reaction factor had been altered, and whether or not the distinguishing morphological characters were heritable. In time perithecia developed in matings of *aborta* with *normal A* (3-3) as well as in check matings of the two *normal* tester-strains. No perithecia were formed in any matings of *aborta* with *normal a* (3-14). This proved the sexual reaction of the variant to be the same as that of the *normal* strain (3-14, *a*) from which it was derived. The hybrid perithecia were noted to be considerably smaller than *normal* inbred perithecia, varying from one-third to two-thirds the size of the latter.

Microscopic examination of hybrid perithecia revealed the most striking effect of the *aborta* strain, namely, that *all fertile asci bore 4, rather than 8, ascospores*, the latter number being typical of *normal* inbred asci of *H. Ipomoeae*. Moreover, very few fertile hybrid perithecia were formed, and in those the number of fertile asci was very low. Three possible explanations of the above phenomenon were suggested: (1) the *aborta* strain either possessed a factor which inhibited ascospore formation or lacked the factor or factors for ascospore formation; (2) each of the four spores in the hybrid asci contained two of the eight nuclei resulting from the normal division processes accompanying ascospore formation, as is the case in *Neurospora tetrasperma* and certain other fungi; and (3) the usual third nuclear division preceding delimitation of ascospores was omitted. If the first explanation is correct, no *aborta* cultures should appear in the progeny of *aborta* \times *normal* perithecia. If the second explanation is correct, the hybrid population should consist either (a) of pure *normal* cultures and pure *aborta* cultures in equal numbers, or (b) wholly of mixed *aborta-normal* cultures, or (c) of pure *normal*, pure *aborta*, and mixed *aborta-normal* cultures in somewhat uncertain ratios. If the third explanation is correct, the progeny should consist of pure *normal* and pure *aborta* cultures in equal numbers.

To clarify this question and provide further information concerning *normal* \times *aborta* hybrids, a total of 311 single-ascospores

were isolated from six hybrid perithecia and planted on potato-dextrose agar slopes. Each spore was examined under the microscope, in most cases using the 45 \times objective, to insure its purity before transferring to the agar slope. Since the hybrid perithecia were ostiolate and discharged their spores spontaneously, it seemed reasonable that these spores, like conidia (Dimock, 4), might function in the spermatization of the perithecial fundaments produced by the *normal* parent hyphae. If such secondary perithecia were formed, many of them would be inbred rather than hybrid. All perithecia to be used for ascospore isolation were therefore crushed in sterile water and examined microscopically prior to spore isolation as a precaution against unwittingly employing *normal* inbred perithecia in place of *aborta* \times *normal* hybrids. This precaution was fully justified by subsequent observations which showed that after the first hybrid perithecia were produced, secondary *normal* inbred perithecia developed in such abundance that it became difficult to find hybrids.

Of the 311 single ascospores thus obtained from *normal* \times *aborta* perithecia, 273 developed *normal* cultures, 32 developed "purple" type cultures, 4 developed distinctly new types of cultures, and 2 gave rise to cultures which appeared to be of the *aborta* type. The "purple" type cultures were similar to those which had been obtained from *normal* inbred perithecia in earlier studies (Dimock, 4). The four new types were quite distinct from one another and from the two parent strains, and did not appear to be intermediates. The "purple" type and the four new types will be discussed more fully in a later paper. In anticipation, however, it should be noted here that the appearance of the "purple" type apparently results from the conversion of a "mutable gene" of the *normal* complex during maturation of the zygote nucleus, and that such conversion is reversible. Hence, in a discussion of *normal* vs. *aborta*, the "purple" type may be considered as *normal*.

The high percentage of *normal* cultures (including "purple" type) in the f_1 population, namely, 98 per cent, suggested that the theoretical expectancy should be 100 per cent, or in other words, that the first explanation offered to account for the four-spored character of *aborta* \times *normal* asci was correct. Were such the

case, no *aborta* cultures should appear in the hybrid progeny; hence, the two *aborta* cultures which did appear received special attention. A very important feature of these cultures was that each had a sector of apparently *normal* growth originating from the inoculum. Single-spore isolations proved that in each case both *aborta* and *normal* hyphae were present. This observation indicated that in these cases a germinating *aborta* microspore had been carried over with a *normal* ascospore. Were this true, doubt would be cast upon the reliability of the entire investigation. The alarm thus caused was dispelled when it was determined that one of the *aborta* cultures bore sexual-reaction factor *A*, and the other the factor *a*. Conidial contaminants could have borne only the factor *a*. The *normal* components of these cultures possessed the same sexual-reaction factors as the respective *aborta* components.

The above observations led to the conclusion that the two ascospores yielding mixed *aborta-normal* cultures contained both *normal* and *aborta* nuclei. Such a condition could arise if, on rare occasions, more than one nucleus were included in a single ascospore as the result of some abnormality in ascospore delimitation in hybrid asci. If, then, an *aborta* nucleus were fortuitously included in an ascospore delimited by a *normal* nucleus, the developing mycelium would be mixed, containing both *aborta* and *normal* components, as in the above cases. The fact that *aborta* strains appeared in the f_1 population only in such mixed cultures offers strong support to the hypothesis, previously stated, that *aborta* nuclei either lack the factor for ascospore delimitation or possess its recessive allelomorph. The hypothesis is further supported by the fact that in crosses between the two f_1 *aborta* strains and the *normal* tester-strains the primary perithecia bore only 4-spored asci, just as in the original hybridization.

If the assumption is valid that ascospores including more than one nucleus may in rare instances be delimited in *normal* \times *aborta* asci, it might well be proposed that nuclei bearing opposite sexual-reaction factors would occasionally be included in a single ascospore. This indeed proved to be the case, for in two single-ascospore cultures of the above population fertile perithecia were formed. The possibility that contamination had occurred in these two cases cannot, unfortunately, be disproved. It may be recalled,

however, that each bit of agar bearing an isolated germinating ascospore was given careful microscopic examination prior to transfer to the culture tube. Furthermore, although over 1000 single-ascospore cultures from both inbred and hybrid perithecia have been critically observed during this investigation, perithecia

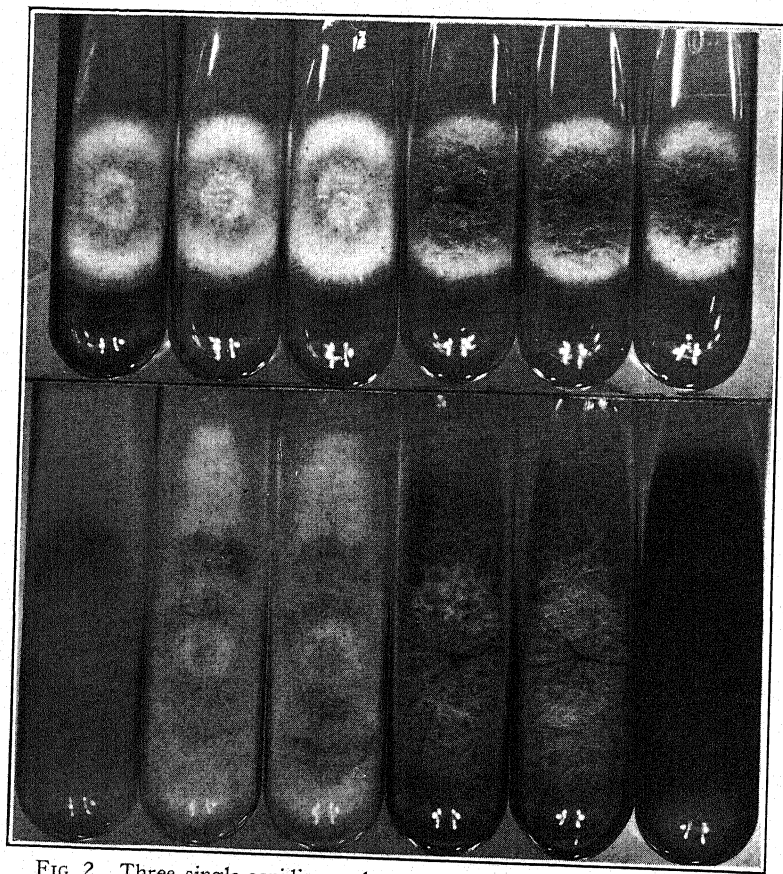


FIG. 2. Three single-conidium cultures each of normal and aborta strains on potato-dextrose agar. Upper, cultures 4 days old; lower, cultures 9 days old.

were found only in these two single-ascospore cultures derived from *aborta* \times *normal* hybrid perithecia.

The distribution of the sexual-reaction factors in the other 309 f_1 cultures is indicated in Table 1. Since it has been shown

(Dimock, 4) that sexual reaction in *Hypomyces Ipomoeae* is determined by a single allelomorphous factor-pair, a one to one distribution of sexual-reaction factors should be expected in the present case unless the genes for ascospore delimitation and those for sexual reaction are linked. The data indicate that no such linkage exists, for were such the case a cross-over value far in excess of 50 per cent would have to be assumed to explain the observed *A/a* ratio.

TABLE 1
FACTOR DISTRIBUTION IN THE PROGENY OF *normal* × *aborta* PERITHECIA

| Perithecium | Normal ^a | | Aborta ^b | |
|-------------|---------------------|-----|---------------------|----|
| | LA ^c | La | lA | la |
| T3..... | 25 | 37 | 0 | 0 |
| T4..... | 3 | 5 | 0 | 0 |
| T5..... | 19 | 33 | 0 | 0 |
| T6..... | 53 | 64 | 0 | 1 |
| T7..... | 20 | 23 | 0 | 0 |
| T8..... | 15 | 10 | 1 | 0 |
| Totals..... | 135 | 172 | 1 | 1 |

^a Includes also new variant types other than *aborta*.

^b Actually "mixed" ascospores. *Normal* components not considered separately.

^c l = recessive for *aborta* characters, L = dominant *normal* allelomorph; *A/a* = sexual-reaction factors.

The f₁ *aborta* strain which bore sexual-reaction factor *A* was backcrossed with the *aborta* parent strain which, as noted, bore sexual-reaction factor *a*. No perithecia, nor even perithecial fundaments, were produced in such matings. The difference in sexual reaction between the two *aborta* strains was verified by repeated matings with the *normal* tester-strains.

DISCUSSION

The foregoing work has shown that variation of a striking sort may be induced by cultivating gameophytic mycelium of *Hypomyces Ipomoeae* on medium containing a sub-lethal concentration of a zinc salt. The claim is not that the mutation considered was a specific effect of zinc ion, the writer inclining to agree with Schiemann (6) and Waterman (8) that the effect is one of dis-

turbed metabolic processes which might result from any one of many factors.

The outstanding feature of the mutant strain, *aborta*, is that 4, rather than 8, spores are delimited in each fertile *normal* \times *aborta* ascus. The data suggest that this phenomenon may best be explained by the assumption that a single gene or gene-complex determining ascospore delimitation has either been deleted or inactivated. Dodge (5) proposes that a somewhat similar strain of *Neurospora tetrasperma*, whose parentage may be traced to an abnormal strain which originated from an X-ray-treated ascospore, bore a recessive factor, *l*, lethal for spore formation in asci homozygous for this factor. *Normal* strains of *N. tetrasperma* were assumed to bear its dominant allelomorph, *L*, which determined ascospore delimitation. Thus, in matings between *l* strains bearing opposite sexual-reaction factors, ascospore abortion was complete, whereas in hybrid (*Al* \times *aL* or *AL* \times *al*) asci numerous ascospores were formed. It is significant that in such hybrid asci some uninucleate spores were delimited whose single nuclei bore only the allelomorph *l*; hence, the effect of this factor was not a simple inhibition of ascospore delimitation, but rather, as Dodge demonstrated cytologically, an interference with maturation of the zygote nucleus such that the eight daughter nuclei in asci homozygous for *l* disintegrated and thus could not delimit spores.

The *aborta* strain of *Hypomyces Ipomoeae* differs from the *N. tetrasperma* strain described by Dodge in two respects: (1) neither perithecia nor asci are formed in matings between *aborta* strains of opposite sexual reaction; (2) *aborta* nuclei are incapable of delimiting spores in *normal* \times *aborta* hybrid asci, but may in rare instances be fortuitously included in ascospores delimited by *normal* nuclei. The present observations, however, warrant the assumption that the *normal* strain bears a factor or factor-complex determining ascospore delimitation which, following Dodge, will be designated *L*, and that the *aborta* strain bears its recessive allelomorph, *l*, which effects inhibition of ascospore delimitation. The striking morphologic characters exhibited by *aborta* are apparently determined by the same factor, *l*, or by a closely linked factor. While the appearance of the *aborta* cultures in the f_1 progeny of the *normal* \times *aborta* hybrids at first suggested crossing-

over between factors for ascospore delimitation and factors for morphologic character, the suggestion was proved groundless by the fact that only 4-spored asci were formed in the hybrid asci which developed when these two cultures were mated with the *normal* tester-strains.

It should be noted that the *aborta* strain is not fitted to compete successfully with the *normal* strain under the environmental conditions prevailing in this investigation. This is evident from the facts (1) that conidium formation by the *aborta* strain is quite poor when compared with the *normal*, (2) that the *aborta* strain does not inbreed, and (3) that *aborta* nuclei in hybrid asci do not delimit spores. A chance observation bearing on this point should be of interest. The original f_1 *aborta* A culture was, as previously noted, predominantly of the *aborta* type, but possessed a small wedge sector of *normal* mycelium in the upper half of the tube. Twenty single conidia were isolated from the upper portion of this culture when it was 6 days old. Of these, 18 developed *aborta* and 2 developed *normal* cultures. All of these *aborta* A cultures were by accident discarded, and to recover the strain in pure culture, 20 more single conidia were isolated from the lower portion of the original culture when it was 25 days old. This time 19 of the developing cultures were *normal*, and only one was *aborta*. Close scrutiny of the original culture revealed that the *normal* mycelium had grown down over the *aborta* mycelium to within about 1 cm. of the bottom of the latter. Twelve single microspores were therefore isolated from this remaining centimeter of *aborta* growth when it was 29 days old. All of these yielded pure *aborta* cultures. In time the *normal* completely overgrew the *aborta* mycelium in the original culture.

SUMMARY

A striking variant has been produced by cultivation of monokaryotic hyphae of *Hypomyces Ipomoeae* on medium containing a sub-lethal concentration of zinc nitrate.

Analyses of 5 consecutive single-conidium culture-series, consisting of 25 cultures each, have proved the mutant strain, *aborta*,

to be homocaryotic. Single-conidium and mass-transfer cultures of the *aborta* strain have shown a high degree of uniformity.

The most striking feature associated with the variant was that four, rather than eight, spores were formed in *aborta* \times *normal* asci, due apparently to inability of nuclei carrying the *aborta* factors to delimit spores.

Evidence strongly indicated that in rare instances ascospores in *aborta* \times *normal* asci may include more than one of the eight nuclei resulting from maturation of the zygote nucleus. Thus, in two instances, single ascospores isolated from hybrid perithecia yielded mixed cultures containing both *normal* and *aborta* hyphae. The two f_1 *aborta* strains thus obtained bore opposite sexual-reaction factors. In two other instances, single ascospores from hybrid perithecia yielded cultures containing *normal* hyphae of both sexual reactions, as was evidenced by the appearance of fertile perithecia in both cultures.

The inability of *aborta* nuclei to delimit ascospores may be attributed to the inactivation or to the deletion of one or more genes determining ascospore delimitation. The ascospore-delimitation factors and the sexual-reaction factors are in different linkage groups.

The genic alteration or mutation, although having occurred on medium containing a sub-lethal concentration of zinc, cannot be considered a specific effect of zinc ion without further evidence.

DIVISION OF PLANT PATHOLOGY,
UNIVERSITY OF CALIFORNIA,
BERKELEY, CALIFORNIA

REFERENCES

1. Arcichovskij, V. Zur Frage über den Einfluss von $ZnSO_4$ auf eine Reihe von Generationen von *Aspergillus niger*. Zentralbl. Bakt. II. 21: 430. 1908.
2. Brierley, W. B. On a form of *Botrytis cinerea* with colorless sclerotia. Phil. Trans. Roy. Soc., London, Ser. B 210: 83-114. 1920.
3. Dimock, A. W. Variation in a species of *Fusarium* induced by high concentrations of zinc salts. Zentralbl. Bakt. II. 95: 341-347. 1936.
4. —. Observations on sexual relations in *Hypomyces Ipomoeae*. Mycologia 29: 116-127. 1937.

5. Dodge, B. O. A recessive factor lethal for ascospore formation in *Neurospora*. Bull. Torrey Club 62: 117-128. 1935.
6. Schiemann, E. Mutationen bei *Aspergillus niger* van Tiegham. Ztschr. Ind. Abstamm. Vererbgs. 8: 1-34. 1912.
7. Tu, Chih. Physiologic specialization in *Fusarium* spp. causing head-blight of small grains. Minn. Agr. Exp. Sta. Tech. Bull. 74: 3-24. 1930.
8. Watermann, H. J. Mutationen bei *Penicillium glaucum* und *Aspergillus niger*. Zeitschr. Gar. Physiol. 3: 1-14. 1913.

TWO CANADIAN COLLECTIONS OF *CANTHARELLUS MULTIPLEX*¹

IRENE MOUNCE AND HENRY A. C. JACKSON

(WITH 1 FIGURE)

In 1898 Mrs. Elizabeth W. Woodworth collected an unusual fungus in a Maine woods and made the following notes about it: "Growing in a large irregular mass and weighing one to three pounds. . . . The color of the fresh pileus was dull purple or purplish lead color, the flesh was decidedly purple, tender and brittle; spores white or whitish, very abundant, dusting the entire plant; height six to twelve inches; taste mild, odor aromatic. The plant suggested to me curly cabbage . . . every curly edge having a silver line, perhaps from the light colored spores. . . ."

In 1899 Underwood (1) assigned the name *Cantharellus multiplex* to this fungus and published the following description:

"Cespitose-multiplex from a compact base which is nearly black when dry; pilei more or less flabellate, compound, 3-5 cm. wide, nearly as long, blackish above in drying, cinereous beneath and concolorous to the base of the stipe where it joins the blackish base; stipe 2-4 cm. long, often deeply grooved above by the decurrent margins of the pileus, occasionally somewhat tubular by their union along the outer edges; hymenium radiately venulose-reticulate with irregular cross veinlets and frequent minute slit-like fissures and larger irregular depressions; spores copious, 5-6 μ in diameter often appearing coarsely lobed when freshly moistened as though formed of united granules.

"On the ground in dense woods of spruce and fir, Seal Harbor, Mt. Desert, Maine, August 1898."

He noted, however, "the plant is a remarkable one and from its habit might well form a distinct genus since it has little in common with *Cantharellus* except its fold-like gills."

In 1910 Murrill (2) founded the genus *Polyozellus* consisting of the single species *P. multiplex* on these specimens collected by

¹ Contribution No. 483 from the Division of Botany, Experimental Farms Branch, Department of Agriculture, Ottawa, Canada.

Mrs. Woodworth. He failed, however, to mention the characteristic rough walled spores.

Since, as far as we are aware, no further collections of this

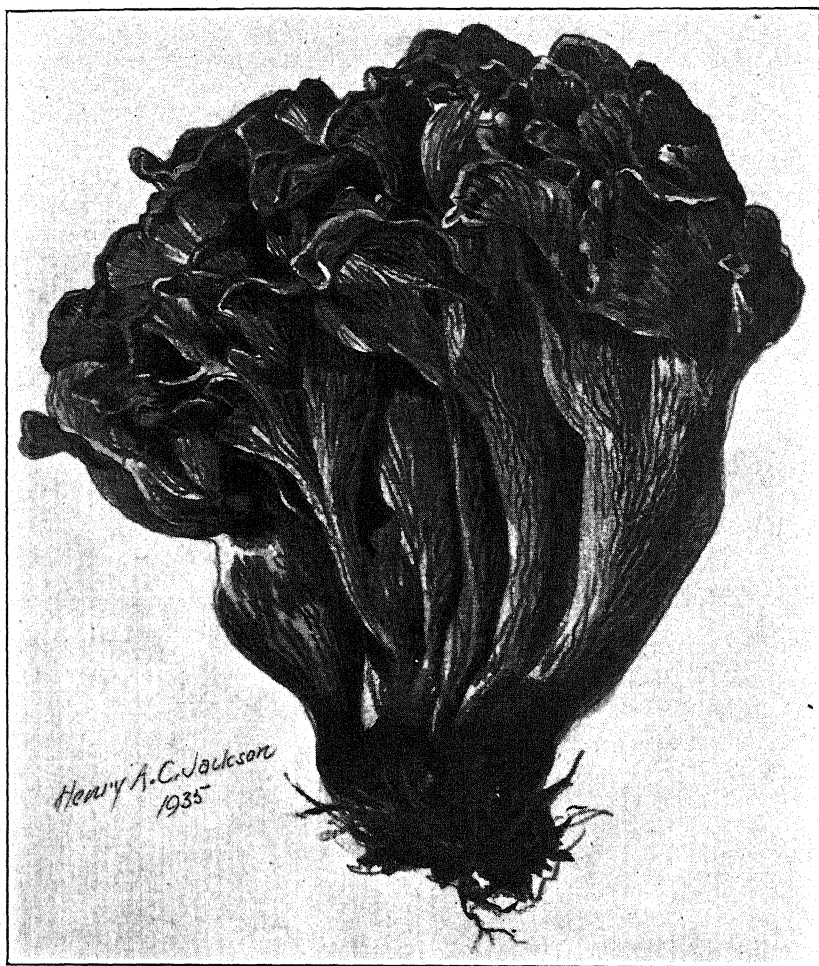


FIG. 1. *Cantharellus multiplex* Underwood [*Polyozellus multiplex* (Underw.) Murr.]. A drawing of the St. Come specimen made from fresh material. Natural size.

fungus have been recorded, two which were made in Quebec recently may be of interest. The first of these collections was made by the junior author who found the specimen, illustrated in the

accompanying drawing (FIG. 1), beneath trees in a mixed woods at St. Come, Quebec, on September 8, 1935. The specimen is now in the herbarium of the Division of Botany. The second collection was sent to the Division of Botany by Mrs. Charles A. Lewis, who found the fungus growing in "a mass of one to three feet" in a dry spruce woods at Metis Beach, Quebec, on July 31st, 1936. Parts of this collection have been sent to The New York Botanical Garden, the Farlow Herbarium, Pennsylvania State College Herbarium, and to The Herbarium at Kew. None of the specimens reaches the height as given by Mrs. Woodworth but the form, color, and spores are characteristic of this species.

Our thanks are due to Dr. L. O. Overholts for identifying the Metis specimen and comparing it with type material kindly loaned by Dr. F. J. Seaver, and to Mrs. Charles A. Lewis who, at a good deal of inconvenience to herself, obtained further material for us from Metis Beach.

DIVISION OF BOTANY,
EXPERIMENTAL FARM,
OTTAWA, CANADA

LITERATURE CITED

1. Underwood, L. M. A new *Cantharellus* from Maine. Bull. Torrey Club 26: 254-255. 1899.
2. Murrill, W. A. North American Flora 9: 171. 1910.

HYDROGEN ION CONCENTRATION AND ASCUS FORMATION

LEWIS B. LOCKWOOD¹

In the course of a study of the nutrition of *Penicillium* (*Car-penteles*) *javanicum* van Beijma, the cultures were maintained on cornmeal agar. Perithecia were produced abundantly on this medium. The fungus also produced an indicator pigment, the structure of which is not known. When the agar medium is made with the clear extract of cornmeal, the pH of the medium is such that the pigment is red, but if some debris or solid part of the cornmeal is allowed to mix with the agar, the color is yellow. It was observed that if some cornmeal debris were allowed to settle into the bottom of a test tube before pouring the plates, the debris was not spread uniformly throughout the plate, thus giving areas in which each color prevailed. Examination of perithecia from such a plate revealed that most of the perithecia from the yellow areas were filled with gas, and most of the perithecia from the red areas were filled with asci.

To further investigate this phenomenon, *Penicillium javanicum*, *Aspergillus herbariorum* ser *minor* (Mangin) Thom and Church, and *Chaetomium globosum* Kunze were grown on synthetic media with the pH regulated by a modified McIlvaine's system of buffers as follows:

| pH ² | 0.1 M Citric Acid | 0.2 M K ₂ HPO ₄ |
|-----------------|-------------------|---------------------------------------|
| | cc. | cc. |
| 2.1..... | 60 | 0 |
| 3.1..... | 45 | 15 |
| 4.0..... | 35 | 25 |
| 5.0..... | 28 | 32 |
| 6.1..... | 20 | 40 |
| 7.1..... | 8 | 52 |
| 8.5..... | 0 | 60 |

¹ 270th Contribution from the Industrial Farm Products Research Division, Bureau of Chemistry and Soils, United States Department of Agriculture, Washington, D. C.

² Determinations were made with a glass electrode by Dr. James McLaren of this Division.

Nutrients were added, and the volumes of solutions made up to 75 cc. For *P. javanicum* and *A. herbariorum* ser. minor, 10 cc. buffered nutrient medium was transferred to each Petri dish which contained 10 cc. washed silica gel. For *C. globosum*, 10 cc. buffered nutrient solution was added to three sterile 9 cm. filter papers in each Petri dish. The nutrient medium for *P. javanicum* contained in addition to the buffers, 250 gms. glucose, 4 mgs. H_3PO_4 , 40 mgs. $MgSO_4 \cdot 7H_2O$, 8 mgs. KCl and 18 mgs. NH_4NO_3 per liter. For *A. herbariorum* ser. minor and *C. globosum*, the nutrients were 50 gms. glucose, 80 mgs. $MgSO_4 \cdot 7H_2O$, 8 mgs. H_3PO_4 , 16 mgs. KCl and 18 mgs. NH_4NO_3 per liter. Cultures of *P. javanicum* were 21 days, of *A. herbariorum* ser. minor 25 days, and of *C. globosum* 26 days old at harvest. All cultures were made in triplicate.

Counts of all mature perithecia in several areas of each plate were made. Data presented in Table I show that in the three organisms, the greatest percentage of ascus-bearing perithecia occurs toward the alkaline range. The color of the indicator pigment of *P. javanicum* is yellow in acid media, changing to red in alkaline media at about pH 6.

No variation in the number of perithecia produced which might be attributed to variation in hydrogen ion concentration was observed.

TABLE I
FERTILITY OF PERITHECIA OF THREE FUNGI GROWN AT VARIOUS HYDROGEN ION CONCENTRATIONS

| pH | <i>Penicillium javanicum</i> | | <i>A. herbariorum</i> ser. minor | <i>C. globosum</i> |
|-----|-------------------------------|--------------------|-------------------------------------|--------------------|
| | Color ¹ | Per Cent with Asci | Per Cent with Asci | Per Cent with Asci |
| 2.1 | Baryta Yellow (Pl. IV) | 1.0 | — ² | — ² |
| 3.1 | " " " | 0.5 | — ² | — ² |
| 4.0 | " " " | 1.0 | 0 | — ² |
| 5.0 | " " " | 9.0 | 59 | — ² |
| 6.1 | Pale ochraceous buff (Pl. XV) | 4.0 | 84 | 1 |
| 7.1 | Light jasper red (Pl. XIII) | 73.2 | 100 | 16 |
| 8.5 | — ³ | 97.7 | 100 | 44 |

¹ Ridgeway, Robert, 1912, Color Standards and Color Nomenclature. Washington, D. C.

² No growth.

³ The brown color of the caramelized sugar prevented matching this color.

PASCHER AND THE GENUS ASTERO- CYSTIS OF DE WILDEMAN

J. S. KARLING

In 1893 De Wildeman described *Asterocystis* as a new genus of chytrids for an *Olpidium*-like species with somewhat star-shaped resting spores. This genus was recognized by most students of the Olpidiaceae for two decades, but in 1917 Pascher, the well known European algologist, published a short article maintaining that the same name had already been given by Gobi (1879) to a red alga of the family Bangiaceae with stellate chromatophores. He accordingly suggested that *Asterocystis* in the sense of De Wildeman be dropped, and proposed as an alternative the more descriptive name *Olpidiaster*. His suggestion was adopted by Hösterman and Noack (1923), Kirchner (1923), Heald (1926, 1933), Gäumann (1926), Gäumann and Dodge (1928), Fitzpatrick (1930), Hildebrand (1934), and others. Fitzpatrick in particular calls attention in his synonymy to the claim that *Asterocystis* De Wildeman is antedated by *Asterocytis* Gobi.

A careful comparison, however, of the two names shows at once that Gobi's genus differs by the lack of an "s" in the third syllable, and it is thus obvious that on the basis of orthography there is no ground for dropping De Wildeman's generic name. Pascher's contention is difficult to understand in view of the fact that in 1895 (p. 226) De Wildeman called specific attention to this difference; and Pascher himself was apparently aware of it (1925, Heft 11: 159) in his book on the freshwater algae of Germany, Austria and Switzerland. The orthography of the two names is none the less almost the same, and Pascher at first glance apparently came to the conclusion that they were identical. As far as I have been able to determine he has never corrected this error of 1917. Obviously, those who subsequently adopted *Olpidiaster* as an alternative accepted Pascher's statement as correct, and did not examine the original descriptions of the two genera.

While the generic name *Olpidiaster* is perhaps more descriptive of the complete life cycles of the species to which it relates than *Asterocystis*, and its adoption would doubtless eliminate the possibilities of confusion with Gobi's genus, there seems to be no good reason in light of present day knowledge for recognizing either of them as distinct from *Olpidium* and as a well-defined, valid chytrid genus. De Wildeman's original description related only to the resting spores of *Asterocystis*, which he claimed differed from those of *Olpidium* by being stellate with a thin membrane or envelope, possessing a large refractive globule in the center, and not becoming plasmolysed by treatment with glycerine. The first of these characters, however, does not appear to be specific or generic, since Woronin (1878), Dangeard (1886), Nemec (1912), Bensaude (1923) and Bartlett (1928) have found stellate spores in *Olpidium* also. Thus, as Guyot (1927) has already pointed out the distinction on the character of the resting spore no longer seems tenable. Guyot has furthermore shown in his extensive study that the refractive globule varies in size in *Asterocystis*, and that the resting spores can be readily plasmolysed; thus breaking down De Wildeman's other two generic distinctions.

In 1901 Marchal discovered the zoösporangia of *Asterocystis* for the first time, and described them as lacking exit tubes for the liberation of the zoöspores. The latter, according to him, escaped through a lateral opening near one of the extremities, and on the basis of this new character he maintained that the two genera could be more clearly separated. It is to be noted, however, that since his time species of *Olpidium* have also been described (Kusano, 1912; Schwartz and Cook, 1928) without exit tubes or with only short papillae for the liberation of the zoöspores. Furthermore, Guyot, Vanterpool (1930) and others have since shown that long exit tubes may frequently develop in *Asterocystis* also. These recent studies have also shown that there is no fundamental difference in the size, shape and appearance of the zoösporangia and zoöspores.

These similarities together with the fact that species of both genera have been reported to parasitize the same hosts and produce similar effects, indicate, it seems to me, that there is no basic distinction between the two as far as our knowledge goes at the

present time. Perhaps as Guyot has suggested, future cytological studies may justify de Wildeman's genus, but there is no good evidence at hand to separate it from *Olpidium* at the present time. The number of root inhabiting species of *Olpidium* has been rapidly increasing in the past few years, and it is becoming imperative that intensive cross inoculation experiments coupled with morphological and cytological studies be made before we can determine the validity of the new species conclusively.

COLUMBIA UNIVERSITY,
NEW YORK, N. Y.

BIBLIOGRAPHY

- Bartlett, A. W. 1928. *Olpidium radicum* de Wildeman and the "hybridization nodules" of swedes. Trans. Brit. Mycol. Soc. 13: 221-238.
- Bensaude, M. 1923. A species of *Olpidium* parasitic in the roots of tomato. Phytopath. 13: 451-454.
- Dangeard, P. A. 1886. Recherches sur les organismes inferieurs. Ann. Sci. Nat. VII. 4: 241-341.
- De Wildeman, E. 1893. Notes Mycologiques I-III. Ann. Soc. Belge Micro. 17: 5-30.
- . 1895. Notes Mycologiques XX. Ibid. 19: 215-228.
- Fitzpatrick, H. M. 1930. The lower fungi—Phycomycetes.
- Gaumann, E. 1926. Vergleichende Morphologie der Pilze. Jena.
- Gaumann, E. & C. W. Dodge. 1928. Comparative morphology of fungi. New York.
- Gobi, C. 1879. A short report on an algological investigation made during the summer of 1877 in the Gulf of Finland. Trudy Soc. Nat. St. Petersburg 10: 83-92.
- Guyot, A. L. 1927. Contributions a l'etude systematique et biologique de l'*Asterocystis radialis*. Ann. Epiph. 13: 79-93.
- Heald, F. D. 1926. Manual of plant diseases.
- . 1933. Manual of plant diseases. 2nd ed.
- Hildebrand, A. A. 1934. Recent observations on root rot in the Niagara Peninsula. Canadian Jour. Res. 11: 18-31.
- Höstermann, G. & M. Noack. 1923. Lehrbuch der pilzparasiten Pflanzenkrankheiten.
- Kirchner, L. 1923. Die Krankheiten und Beschädigungen unserer Landwirtschaftlichen Kulturpflanzen. Stuttgart.
- Kusano, S. 1912. On the life history and cytology of a new *Olpidium* with special reference to the copulation of motile isogametes. Jour. Tokyo Coll. Agric. 4: 141-199.
- Marchal, E. 1901. Recherches biologiques sur une Chytridinee parasite au Lin. Rev. Mycol. 23: 113-117.

- Nemec, B. 1912. Zur Kenntniss der niederen Pilze IV. *Olpidium Brassicae* Wor. und zwei *Entophlyctis*-Arten. Bull. Int. l'Acad. Sci. Boheme 1912: 1-11.
- Pascher, A. 1917. *Asterocystis* de Wildeman und *Asterocystis* Gobi. Beih. Bot. Centralb. 35²: 578-579.
- . 1925. Die Süßwasserflora Deutschlands, Österreichs, und der Schweiz. 11: 159.
- Schwartz, E. J. & W. R. I. Cook. 1928. The life history and cytology of a new species of *Olpidium*; *Olpidium radicale* sp. nov. Trans. Brit. Mycol. Soc. 12: 205-220.
- Vanterpool, T. C. 1930. *Asterocystis radialis* in the roots of cereals in Saskatchewan. Phytopath. 20: 677-680.
- Woronin, M. 1878. *Plasmodiophora Brassicae*, Urheber der Kohlpflanzenhernie. Jahrb. Wiss. Bot. 11: 548-574.

OBSERVATIONS ON A *MONASCUS* ISOLATED FROM RUBBER¹

ARTHUR L. SCHADE

Late in the summer of 1931, a specimen of crude rubber of *Hevea brasiliensis* at the Harvard Botanical Museum was observed to be covered by a heavy white growth. Among the fungi responsible for this growth was one which, on examination, was found to be *Monascus ruber* van Tieghem. In addition to the moulds, mites were abundant on the specimen. Since the mould flourished wherever the mites had eaten their way into the rubber, it was of interest to determine whether the *Monascus ruber* was growing on a substratum furnished by the mites or on the rubber alone.

This paper reports the growth of *Monascus ruber* on the rubber apart from the mite excrement and gives the results of growth experiments of *Monascus ruber* and *Monascus purpureus* Went on other crude rubbers, on commercial rubbers, and on extracted rubber hydrocarbon.

HISTORICAL

Examination of the literature dealing with the substrata of *Monascus* does not reveal, to the writer's knowledge, any previous report of rubber as a substratum. Van Tieghem (8), who procured his material from a growth on boiled potato, first described the genus in 1884 and named the fungus *Monascus ruber*. Harz (3), in 1890, reported a fungous growth, brought to his attention by a chemist in a candle and soap factory, on a raw glycerin solution of 8-10 per cent concentration. Young (10) includes this fungus, which Harz (3) named *Physomyces heterosporus*, under *Monascus ruber*, a variable species. Another species found on some oil in cans and on skins from a tannery in France was named *Monascus olei* by Piedallu (6). Inspection by Lewis (4) of

¹ Contribution from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University, no. 151.

mycelial growth in a bottle of pickles led him to identify the fungus as *Monascus Barkeri* Dangeard. Yesair (9) found that *Monascus purpureus* caused the development of red areas on sausages. The Orient, probably for centuries, has made use of both the fermenting properties of *Monascus purpureus*, together with a yeast, for the manufacture of alcoholic beverages, and its pigmenting power for the production of colored rice, known in trade as Aga-Koji.

Of some interest is Buchanan's (2) report of *Monascus purpureus* found in silage in this country. Its occurrence was linked with the death of eleven horses although further investigation did not give evidence of any direct relationship between this particular organism and the death of the horses. Recently, Young (10) has made a study of the physiological characteristics of a *Monascus* sp. found in maize flour near Johannesburg, South Africa. It is apparent that the genus *Monascus*, in view of the wide variety of substrata used by the several species, is not closely restricted in its use of nutriment.

MATERIAL AND METHODS

The crude rubber specimen of *Hevea brasiliensis* from which *Monascus ruber* was isolated came from Acre River, Brazil.² On its arrival at the Museum, it was sealed in a glass container. After two years the heavy mould growth was apparent. The presence of *Monascus ruber* in all the mixed cultures of the fungi from the specimen suggests that it was an important constituent of the aggregate growth.

For purposes of comparison, *Monascus purpureus*, usually associated with a carbohydrate substratum, was isolated from rice grains representative of "Koji" material and employed, along with *Monascus ruber*, in all of the growth studies. Throughout all of the experiments and subsequent observations on growth, sterile damp chambers were used. Inoculation of the various test materials was most conveniently effected by pipetting onto the

² Through the interest of Professor Oakes Ames, the mouldy crude rubber slab from the Harvard Museum was turned over to Professor Wm. H. Weston, Jr., to whom the writer is indebted for the subsequent outlining of the possibilities for a research problem which the mould growth offered and to whom the writer wishes to express gratitude for his interest and helpful suggestions.

sample one-fourth of a milliliter of inoculum prepared by scraping masses of conidia and ascospores from the surface of stock culture medium of potato-dextrose agar into ten cubic centimeters of sterile water.

EXPERIMENTAL

To determine whether or not *Monascus ruber* and *Monascus purpureus* were able to use the crude rubber of *Hevea brasiliensis* as a substrate, centimeter cubes unaffected by mites and free from fungi, were cut from the slab and inoculated with spore suspensions of the fungi. After three days at 31° C., both species were growing well on the rubber. That the *Monascus ruber* grew on the crude rubber when separated from the mite material showed that it was not obligately dependent on the activities of the mites for its growth on the museum specimen.

The ability of both species of *Monascus* to grow on a variety of crude rubbers was next investigated. Table I gives the results of this experiment:

TABLE I
GROWTH OF *Monascus ruber* AND *Monascus purpureus* ON VARIOUS CRUDE RUBBERS IN DAMP CHAMBERS AT 31° C. AFTER TWO WEEKS

| Type of Rubber | <i>M. ruber</i> | <i>M. purpureus</i> |
|---------------------------------------------------------|-----------------|---------------------|
| <i>Castilloa elastica</i> (unwashed, undried) | ** | ** |
| <i>Castilloa elastica</i> (washed, dried) | * | * |
| <i>Urecola elastica</i> | **** | *** |
| <i>Landolphia</i> sp. | *** | *** |
| <i>Parthenium argentatum</i> | *** | *** |
| <i>Euphorbia lorifolia</i> | ***** | ***** |
| <i>Ficus elastica</i> | ** | ** |
| <i>Palaquium gutta</i> | *** | ** |

(*)'s indicate relative amounts of mycelial growth.

Despite variations in amounts of growth, all of the crude rubbers inoculated served as nutrient substrata. The differences in growths on the washed and unwashed sample of *Castilloa elastica* may be accounted for by the greater amount of serum³ present in the unwashed sample.

The ability of samples of commercial rubber, representative of

³ That portion of the latex which is not an integral part of the rubber hydrocarbon is called the "serum" and comprises the water, salt, enzyme, protein, sugar, and resin content of the latex.

the several stages attained in preparation of the finished vulcanised product from latex, to support growth of *Monascus ruber* and *Monascus purpureus* was next studied. The samples were supplied by the U. S. Rubber Co. They included latex from *Hevea brasiliensis* preserved with ammonia, first latex pale crêpe, smoked sheet, latex-sprayed rubber, and vulcanised samples made from the above three rubbers.

Table II indicates relative amounts of growth on several types of rubber:

TABLE II
GROWTH OF *Monascus* ON TYPES OF COMMERCIAL RUBBER IN DAMP CHAMBERS
AT 31° C. AFTER TWO WEEKS

| | | Pale Crêpe | Smoked Sheet | Latex-sprayed | 90'' vul. | 210'' vul. |
|---------------------------|----------------------|------------|--------------|---------------|-----------|------------|
| <i>M. ruber</i> | Mycelium | *** | ***** | ***** | — | — |
| | Conidia | **** | ***** | ***** | — | — |
| | Perithecia | *** | ***** | ***** | — | — |
| | Pigment | * | *** | *** | — | — |
| <i>M. pur- pureus</i> | Mycelium | * | ** | ** | — | — |
| | Conidia | * | * | * | — | — |
| | Perithecia | — | — | — | — | — |
| | Pigment | ** | ** | *** | — | — |

(*)'s indicate relative amounts.

Monascus ruber seems to develop somewhat better than *Monascus purpureus* on a rubber substratum especially in the production of perithecia. No growth whatever was produced on the vulcanised samples, a result which is probably due to the presence of sulfur in the rubber since sulfur is recognized generally as inhibitive to growth of fungi. Among the other samples, pale crêpe is least suitable as a nutrient substratum. An explanation of this result may be sought in the method of preparing pale crêpe. The coagulum from the latex is subjected to the action of a stream of water while passing between rollers revolving at uneven speeds so that practically the whole of the serum is washed out. The addition of sodium bisulfite to the latex before coagulation to inhibit the action of an oxidase during the drying of the crêpe may serve the further purpose of inhibiting growth.

The most interesting observation to be made from the above table is the comparative ease with which the fungi made use of

the smoked sheet for nutriment. One of the purposes of smoking is to render the rubber less liable to mould attack through the presence of the phenolic constituents in the smoke. Contrarily, the results indicate that the growth of *Monascus ruber* and *Monascus purpureus* is but slightly, if at all, hindered by the smoking of the sheet. The results obtained with the latex-sprayed rubber are what might be expected from a medium possessing all the constituents of the serum in addition to the caoutchouc portion of the rubber. Several unsuccessful attempts were made to grow the fungi on the latex preserved in ammonia. Since, however, growth was produced on latex-sprayed rubber, it is reasonable to infer that the ammonia made the latex unsuitable for support of the fungi and that untreated latex would readily serve as a substrate.

In order to determine whether or not the serum in the rubber was the sole source of nutriment for the growing fungi, it was deemed desirable to separate the caoutchouc from the serum and observe growth on the hydrocarbon alone. The method employed to obtain the rubber hydrocarbon, a polymer of isoprene, involved the use of petroleum ether as the solvent after the resins had been extracted from the crude rubber by acetone. The sol-rubber was then precipitated in 95 per cent ethyl alcohol. Table III gives the results obtained:

TABLE III
GROWTH OF *Monascus* ON SOL-RUBBER HYDROCARBON IN DAMP CHAMBERS
AT 31° C. AFTER TWO WEEKS

| | Mycelium | Conidia | Perithecia | Pigment |
|---------------------------|----------|---------|------------|---------|
| <i>M. ruber</i> | *** | *** | ** | * |
| <i>M. purpureus</i> | ***** | ***** | ** | * |

(*)'s indicate relative amounts.

The indication that growth of the fungi is possible on the rubber hydrocarbon suggests that in all of the previous experiments the isoprene polymer could have been a source of nourishment.

The writer felt that it would be of added interest to test synthetic rubber for suitability as a nutrient substratum. The E. I. DuPont de Nemours and Company, Inc., furnished samples of the "Plastic Polymer" and of the vulcanized "Du Prene" for

this experimental work. This synthetic rubber is a polymerisation product of chloroprene, comparable to isoprene with the important difference of having the methyl group of isoprene replaced by a chlorine atom.

No growth of *Monascus ruber* or *Monascus purpureus* resulted on either the "Plastic Polymer" or the vulcanized "Du Prene" when inoculated and kept for two weeks in a damp chamber at 31° C. The failure of the fungi to grow suggests either that the chlorine atom of the chloroprene unit had an inhibitory effect on growth, or that the natural polymer of isoprene differs from the artificial polymer of chloroprene so that the latter is less liable to attack by the fungi.

DISCUSSION

The relation that the species of *Monascus* may have to the general problem of moulds on rubber in the light of the results of the foregoing experiments is of interest. Since *Monascus* has been reported in the United States, France, South Africa, and China, we may conclude that it is a cosmopolitan genus. In addition to its demonstrated ability to utilize a rubber medium for nutriment, the variety of other substrata on which it has been found bears witness to its use of a great variety of substances. Consideration of these two attributes of *Monascus*, cosmopolitanism and utilization of many substrata, leads to the conclusion that *Monascus* may become a conspicuous member of the offending types of fungi found on rubber.

The growths of moulds on rubber have given rubber growers much concern in the past. The chief objection to their presence is the spotting which they produce on the plantation rubber. Sharples (7) reported that such spotting was due to common saprophytic fungi and that most of the offending species belong to the genera *Penicillium* and *Aspergillus*. In a study of spots on crude rubber, Paine (5) observed that a bacterium, *Bacillus prodigiosus*, was responsible for the production of small red spots on crepe rubber. He concluded, however, that the majority of spot discolorations on crêpe was to be attributed to fungi rather than to bacteria, and agreed with Sharples that the most prevalent moulds are *Penicillium* and *Aspergillus*.

It is difficult to find in the literature dealing with fungi growing on rubber any precise information as to the particular species involved. The investigators speak of "light mould growths" and "heavy mould growths," "gray-green mould," and "black and yellow, pin head type of mould," etc. The most complete list found is that given for growths observed on crêpe rubber by Brown (1). The crêpe was supporting growths of *Penicillium*, *Aspergillus*, *Fusarium*, and *Cladosporium*. The particular species are not named. The present paper establishes the fact that *Monascus ruber* has been isolated from a mould contamination on crude rubber and that this species and *Monascus purpureus* can grow on a variety of rubber substrata.

SUMMARY

1. *Monascus ruber* van Tieghem is reported found at the Botanical Museum of Harvard University growing on a specimen of smoked crude rubber of *Hevea brasiliensis* attacked by an undetermined species of mite.

2. Both *Monascus ruber* van Tieghem and *Monascus purpureus* Went grew well on the nutriment offered them by the crude rubber apart from any material furnished by the mites.

3. Crude rubbers from various plants served to varying degrees as utilizable media for growth of both species of *Monascus*.

4. *Monascus ruber* developed somewhat better than *Monascus purpureus* on unvulcanized samples of commercial rubber: pale crêpe, smoked sheet, and latex-sprayed rubber. Pale crêpe is the least suitable of these as a nutrient substratum. The smoked condition of the smoked sheet seemed to hinder but little the support of the fungi. No growth of either species was produced on the vulcanized samples.

5. Pure rubber hydrocarbon representing the sol-rubber portion of the hydrocarbon constituent supported growths of both species of *Monascus*.

6. Synthetic rubber, a polymer of chloroprene, was not utilizable as a substrate by either *Monascus ruber* or *Monascus purpureus*.

7. *Monascus*, a cosmopolitan genus found on a variety of substrata may become an important member of the group of fungi attacking rubber.

BIBLIOGRAPHY

1. Brown, W. Mycologist's report. Bull. Rubber Growers Assoc. 6: 684. 1924.
2. Buchanan, R. E. *Monascus purpureus* in silage. Mycologia 2: 99-108. 1910.
3. Harz, C. O. *Physomyces heterosporus* n. sp. Bot. Centralbl. 41: 378-379; 405-411. 1890.
4. Lewis, C. E. Occurrence of *Monascus Barkeri* in pickles. Mycologia 2: 174. 1910.
5. Paine, S. G. Bacteria on crêpe rubber causing spots. Bull. Rubber Growers Assoc. 6: 315. 1924.
6. Piedallu, A. Sur une nouvelle moisissure du tannage a l'huile. *Monascus olei*. Compt. Rend. Acad. Sci. Paris 151: 397-399.
7. Sharples, A. Spotting in plantation rubber due to fungi. (Abs.) Proc. 3rd Internat. Cong. Trop. Agr. London, pp. 172-173. 1914.
8. van Tieghem, M. *Monascus*, genre nouveau de l'ordre des Ascomycetes. Bull. Soc. Bot. Fr. 31: 226-231. 1884.
9. Yesair, J. The action of disinfectants on moulds. (Abs.) Rev. Appl. Myc. 8: 785. 1929.
10. Young, E. M. Physiological studies in relation to the taxonomy of *Monascus* sp. Trans. Wis. Acad. 25: 227-244. 1930.

CENANGIUM MOLLIUSCULUM

EDITH K. CASH

The taxonomy of this fungus came under consideration in comparing it with a discomycete on *Betula lutea* collected by J. W. Groves at South Aurora, Ontario, and received through the courtesy of H. S. Jackson. The specimen was found to agree with one of *Cenangium molliusculum* Schw. on *Betula carpinifolia* in the Michener Collection at Washington. Later a third collection of the fungus was made by C. L. Shear on *Betula* sp. in the Shenandoah National Park, Virginia.

The species was described by Schweinitz in the Synopsis Fungorum in America boreali, p. 239, 1832, as follows:

"2008. 31. *C. molliusculum*, L. v. S., eximia species in *Betula carpinifolia* Mauch Chunk.

"*C. pezizoideum*, aggregatum ac sparsum, saepe invicem adpressum et inde angulatum. Statu madido molliusculum 1-3 lineas latum, nigro olivaceum marginatum. Sicco statu corneo-ceraceum. Sessile, basi tamen contracta. Cupulam refert marginatam subrepandam lobatam, extus olivaceum, disco convexo rugoso, punctato, nigro. Intus substantia eleganter flavo-ferruginea."

The specimen in the Michener Collection on which the following description was based is labeled "in *Betula carpinifol.* Beth. ex Herb. Schw. 2008-31—Syn. Fung." and except for smaller apothecia it agrees very well with the description as published. It should be noted that the locality cited in the description is Mauch Chunk, that on the specimen is Bethlehem, so that it is questionable whether this specimen is the type. However, there is no indication that Schweinitz made more than one collection and there may have been an error in copying the data on the label.

Various characters evident in the specimen indicate that *Cenangium molliusculum* is a species of *Dermatea*, rather than *Cenangium*: notably the small, flat, coriaceous disk, the dark epithecium formed by the branched paraphyses, and the septate spores. As the species, so far as is known, has not been noted in mycological

literature since the original publication, a more complete description is given.

Dermatea molliuscula (Schw.) comb. nov.

Syn.: *Cenangium molliusculum* Schw. Trans. Am. Phil. Soc. II.
4: 239. 1832.

Apothecia sessile, soft when moist, coriaceous when dry, emerging from beneath the bark singly or in groups of 2-3, turbinate to applanate, externally dark brown or slightly olivaceous when moist, hymenium shining black, rough, .5-3 mm. diam., margin brown, distinct, slightly undulate; asci cylindrical-clavate, gradually attenuated toward the base, wall thickened at the apex, 8-spored, $90-110 \times 11-14 \mu$; spores narrow ellipsoid, uniseriate below, biseriate above, straight or more generally slightly curved, at first unicellular then 1-3-septate, hyaline to subhyaline (brown in old, disintegrating asci), $20-23 \times 4-7 \mu$; paraphyses delicate, filiform, branched toward the tip, at first hyaline, becoming dark and granulose, and coalescing to form a dense, dark brown epithecium; hypothecium thick, pale brownish, plectenchymatic, darker at the cortex.

Specimens examined:

On *Betula carpinifolia*, Bethlehem, Pa., ex herb. Schw. (Type?).

On *Betula lutea*, S. Aurora, Ontario, Sept. 25, 1934, J. W. Groves 278, Univ. Toronto Crypt. Herb. 6773.

On *Betula* sp., Shenandoah Nat. Park, Va., along Rapidan River near Hoover Camp, June 26, 1935, C. L. Shear.

BUREAU OF PLANT INDUSTRY,
WASHINGTON, D. C.

THE PERFECT STAGE OF BOTRYTIS CONVOLUTA¹

F. L. DRAYTON

(WITH 9 FIGURES)

The possibility of a genetic connection between *Botrytis* and *Sclerotinia* was advanced by de Bary (1866). Later, in the revised edition of his book (1884), he again refers to this, stating with assurance that *Botrytis cinerea* Pers. is the conidial stage of *Sclerotinia Fuckeliana* (de B.) Fuckel. This statement has been accepted by some mycologists and vigorously rejected by others on the grounds of insufficient evidence. In the early years of this controversy, Ludwig (1892) described *Sclerotinia Galanthi*, indicating that the apothecia were associated with a *Botrytis* form on diseased snowdrops, and he assumed a genetic connection. No opinion can be given in this paper on the validity of these early records for they have not been critically examined. It should be pointed out, however, that in this early work the evidence in support of a *Botrytis-Sclerotinia* connection was based on the association of the two forms on the same substrate, the close resemblance of the disease symptoms, and the similarity of the mycelia and organs of attachment. In the light of our present knowledge, no indisputable case for a genetic connection could be made from observations of this kind.

By means of improved technique, several investigators have demonstrated beyond doubt that the genus *Sclerotinia* exhibits pleomorphism in a number of its species. The first published record of this kind was by Seaver (1917) and Seaver and Horne (1918). These authors established the connection between a *Sclerotinia* and a *Botrytis*, in a fungus attacking the root stocks of *Geranium maculatum*, which they named *Sclerotinia (Stromatinia) Geranii*. Two years later, Godfrey (1919, 1923), in his work on

¹ Contribution No. 477 from the Division of Botany, Experimental Farms Branch, Department of Agriculture, Ottawa, Canada.

the gray mold of castor bean, established the connection between a *Botrytis* of the *cinerea* type and a *Sclerotinia*, giving to it the name *S. Ricini*. Another example to which reference may be made is recorded by van Beyma Thoe Kingma (1927), describing a *Botrytis* isolated from leek seeds which developed apothecia from the sclerotia and in which the conidial stage could be recovered from single ascospore cultures. He named this fungus *Sclerotinia Porri*.

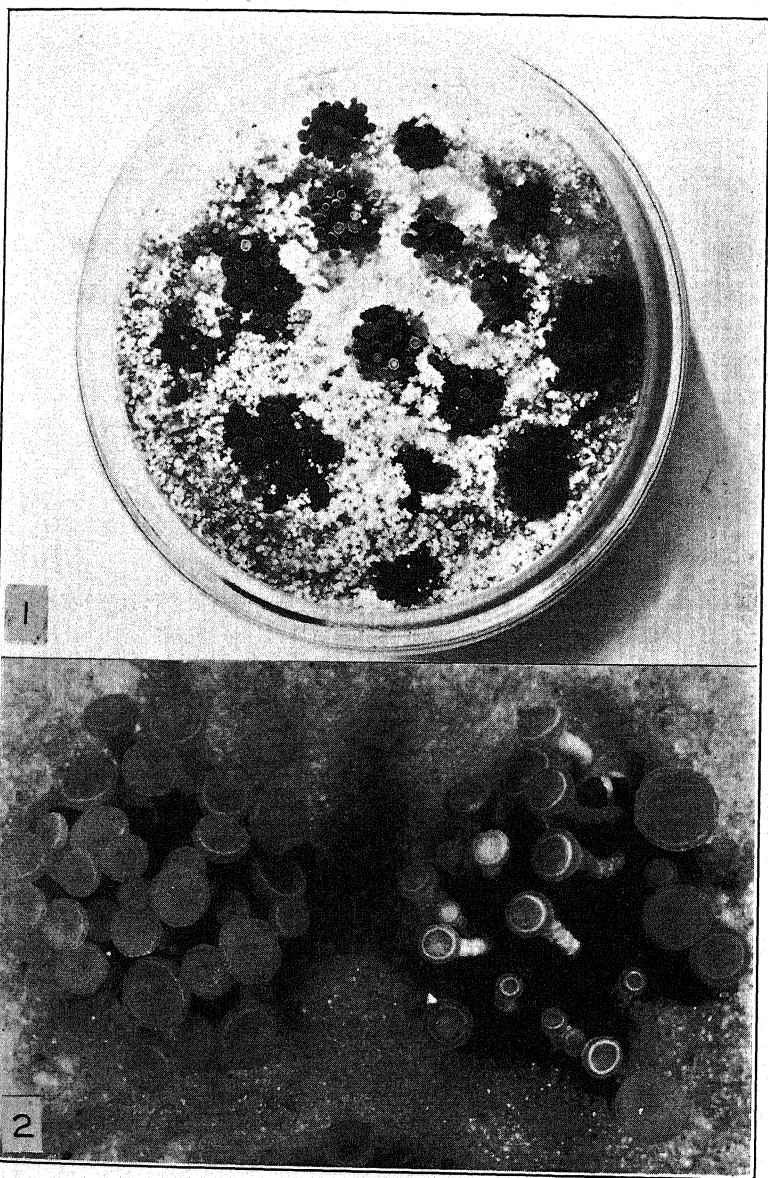
It is now my privilege to record an additional example of a *Botrytis-Sclerotinia* connection. The fungus is one described by H. H. Whetzel and the author (1932) as the cause of a destructive disease of garden iris which was named *Botrytis convoluta*. While the conidiophores and conidia of this fungus are those of a *Botrytis* of the *cinerea* type, the sclerotial masses with their conspicuously convoluted structure are sufficiently distinctive to have warranted the creation of a new species. Microconidia of the type found in species of *Sclerotinia* were also noted, it was then predicted that these would function as spermatia in the production of apothecia. Although no apothecia have so far been observed in nature, they have been obtained in the laboratory under carefully controlled conditions, including the use of microconidia for spermatization.

MATERIAL AND TECHNIQUE

The eight isolates used in this investigation were obtained from diseased iris plants originating in a number of localities as follows: S120 from Germany in 1921, B629 from France in 1922, B673 and B1036 from Ithaca, N. Y., in 1924 and 1931 respectively, B927 from a nursery near Ottawa, Ont., in 1928, B1035 and B.c.25 from Yakima, Wash., in 1931, and Ir2 from St. Paul, Minn., in 1934. I am indebted to Professor Whetzel for the first three cultures, to Dr. Freeman Weiss for the Yakima material, and to Miss Dossdall for the isolate from St. Paul. These cultures are identical, except for slight differences in the readiness with which they produce macroconidia and microconidia, and in the quantity and size of the sclerotia produced. For example S120, B629, and B927 produce fewer sclerotia but far more conidiophores than do

the other five, while the latter, and especially B673, form microconidia more quickly and abundantly.

To obtain sclerotia that will later produce apothecia, the most



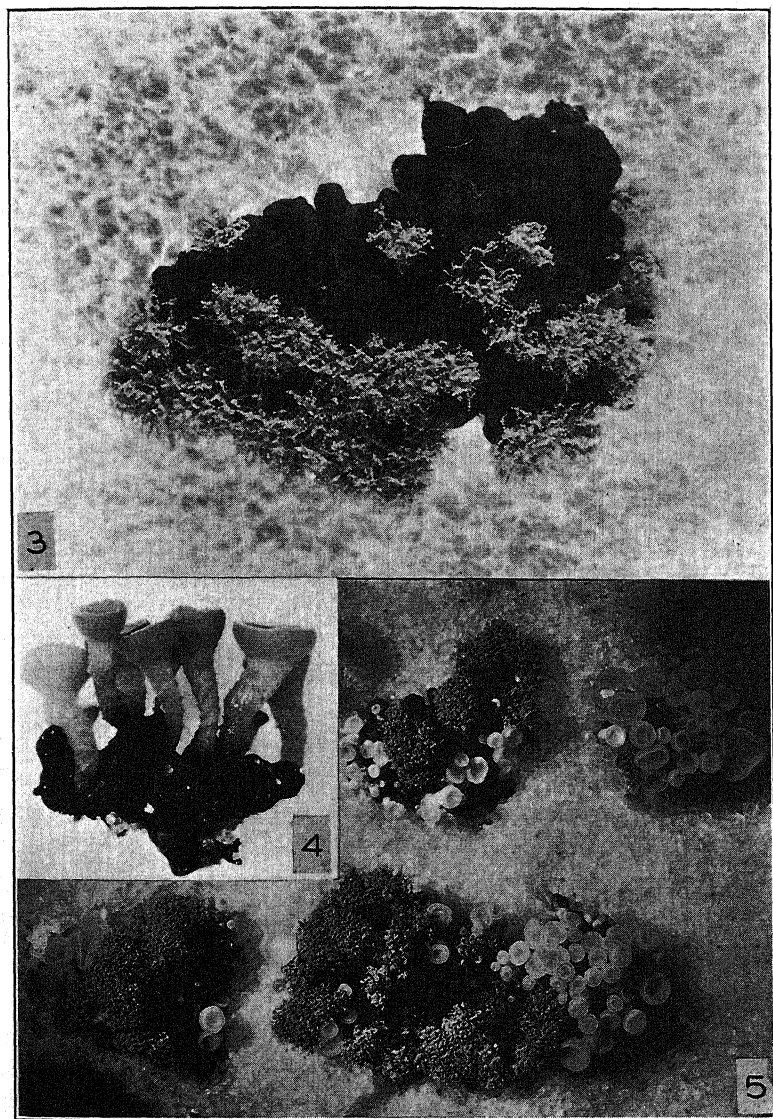
FIGS. 1 AND 2. *Sclerotinia convoluta*.

favorable substrate is the one used in the studies on *Sclerotinia Gladioli* by Drayton (1934a, 1934b). This is prepared by adding 8 grams of wheat grains and 25 cc. of distilled water to each Petri dish and sterilizing in an autoclave for 30 minutes at 15 pounds pressure.

Varying conditions of temperature, illumination, and the period allowed for vegetative growth and development of sclerotia have been tried. The combination that proved to be most favorable for the subsequent development of apothecia is 14° C. and darkness for a period of 45 days. The sclerotial groups are then removed from these cultures and placed in preparation dishes on moistened quartz sand and kept at 0° C. in darkness for a period of 3 or 4 months. After that they are spermatized with microconidia and put at 5° C. for about 5 weeks. The spermatization is done by preparing a soil extract suspension and applying this to the sclerotia with sterilized camel's hair brushes, as described in the paper on *S. Gladioli*. During the latter part of the period at 0° C., apothecial fundaments begin to appear and their production is greatly accelerated after the sclerotia are moved to 5° C. When these structures have attained a length of 2 or 3 mm. the dishes are transferred to the greenhouse and placed under cheese cloth covers. There the temperature is held at about 7° C. at night and not exceeding 15° C. during the day. The apothecia attain maturity in about 4 weeks.

It should be noted that the absence of light is specified not only during the 45-day period of vegetative growth but also during the 3 or 4 months when the sclerotia are held at 0° C. If the cultures are subjected to light during the 45-day period at 14° C., the sclerotia, and particularly those of the isolates S120, B629, and B927, become completely covered with conidiophores and conidia after they are put at 0° C., even if kept in darkness at that temperature. In addition, the same result is obtained if the cultures are kept in darkness at 14° C. for 45 days, but with artificial light admitted to the 0° C. chamber while the sclerotia are on the moist sand. In every case where this prodigious development of conidia has occurred, the sclerotia tend to shrivel and usually fail to produce apothecia.

The admittance of light for a few weeks to the 0° C. chamber in one series of cultures resulted in the formation of some conidio-phores and apothecia on all of the sclerotia in one dish. Part of



FIGS. 3-5. *Sclerotinia convoluta*.

this dish is illustrated (FIG. 5) and is a striking demonstration of the pleomorphism of this fungus.

THE RECEPTIVE STAGE

In the studies on *Sclerotinia Gladioli* it was shown that under favorable treatment, receptive bodies develop from a stroma and that at this stage fertilization and the resulting apothecial development could be brought about by spermatizing with microconidia from a compatible isolate. In the case of the fungus here described, great difficulty has been experienced in determining when the spermatization should be done, for no distinctive receptive structures as such have been recognized. In the absence of a structural indication of this critical stage, three possibilities present themselves. Fertilization may occur when the sclerotia are forming; small groups of trichogynous hyphae may protrude through the rind of the mature sclerotia; or the apothecial initials, which emerge after the period of rest at 0° C., may constitute the receptive structures.

The first hypothesis was tested by a large series of cultures in which spermatization was begun on the 15th day after inoculation, at the first sign of sclerotial development. This was repeated at two-day intervals up to the 25th day. The sclerotia were removed on the 35th day and subjected to the optimum conditions outlined above. No apothecia developed in these cultures, so it appears that this hypothesis is to be discarded. In order to test the second possibility, large numbers of microtome sections of mature sclerotia were cut and stained. These failed to reveal any trace of ascogonial coils or of protruding trichogynous hyphae that might be connected with such coils. That seems to exclude the second possibility. Series of sections made at later dates, however, provided some evidence in favor of the third hypothesis. Sections of sclerotia that had been kept at 0° C. for 4 months showed distinct groups of specialized hyphae just beneath the rind. When it was found that the apothecial initials emerged at a point directly over these hyphae, it seemed likely that they are part of the ascogonial system. It is probable that fertilization cannot take place in the absence of an ascogonium, so it is suggested that the protruding apothecial initial is, in the early stages of its development, the

receptive structure. The fact that in an early culture series apothecia were obtained in a few dishes, only after respermatisation towards the close of the dormancy of the sclerotia, lends strong color to the above theory and provides an explanation for the lack of uniformity in the behaviour of the earlier culture series.

The apothecia illustrated in this paper and used as type material for the description of this ascigerous stage were obtained from only a few cultures in the earlier experiments even though many dishes contained the same isolate and were spermatised with the same microconidia. It is impossible at this time, therefore, to give any definite information on the sexual interaction of the isolates used. This and other facts about the sexual mechanism are being investigated.

It is of interest, however, to point out the apparent reason for this failure to obtain more consistent development of apothecia. In the older series, spermatisation was carried out just after the mature sclerotia were placed on moist sand and prior to placing them at 0° C. Assuming that the receptive stage occurs when the ascogonial initials emerge from the sclerotia, this early spermatisation meant that the microconidia would have to survive the intervening 4 or 5 months at 0° C. in order to effect fertilization. The mucilaginous substance in which the microconidia are borne presumably aids materially in keeping these spores alive for long periods, but in the laboratory process of spermatisation, the microconidia are applied as a suspension in soil extract and a great deal of this protective coating is dissolved. It seems likely that in most dishes the microconidia would become inactivated after 4 or 5 months, but that in a few dishes where moisture conditions happened to be more favorable, the microconidia would survive and fertilize the initials. In the more recent cultures, spermatisation has been done at the later stage, as outlined in the section on technique, and one of these series is sufficiently advanced now to predict a more uniform production of apothecia.

THE GENETIC CONNECTION

In the cultures that yield apothecia, a great many fruiting bodies are produced from each sclerotial group (FIG. 1, 2)—as many as

30 have been counted on a single agglomeration. The apothecia possess all of the morphological features that characterize the genus *Sclerotinia*, but since a detailed description is given in the emended technical description, it need not be repeated here.

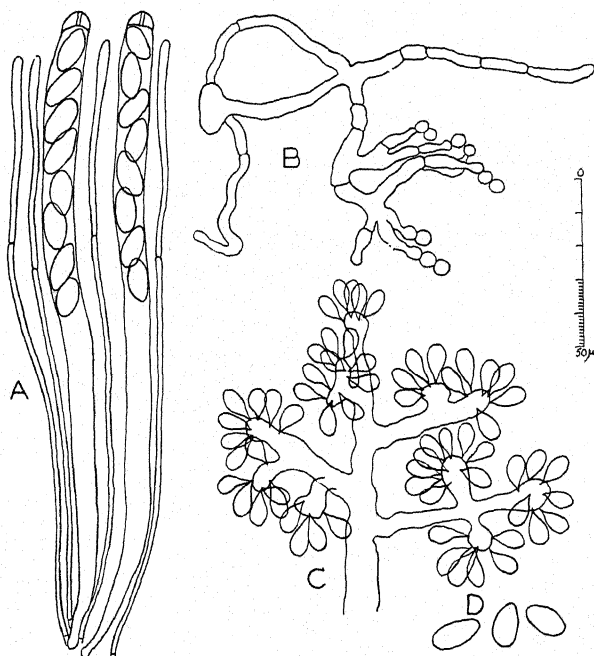
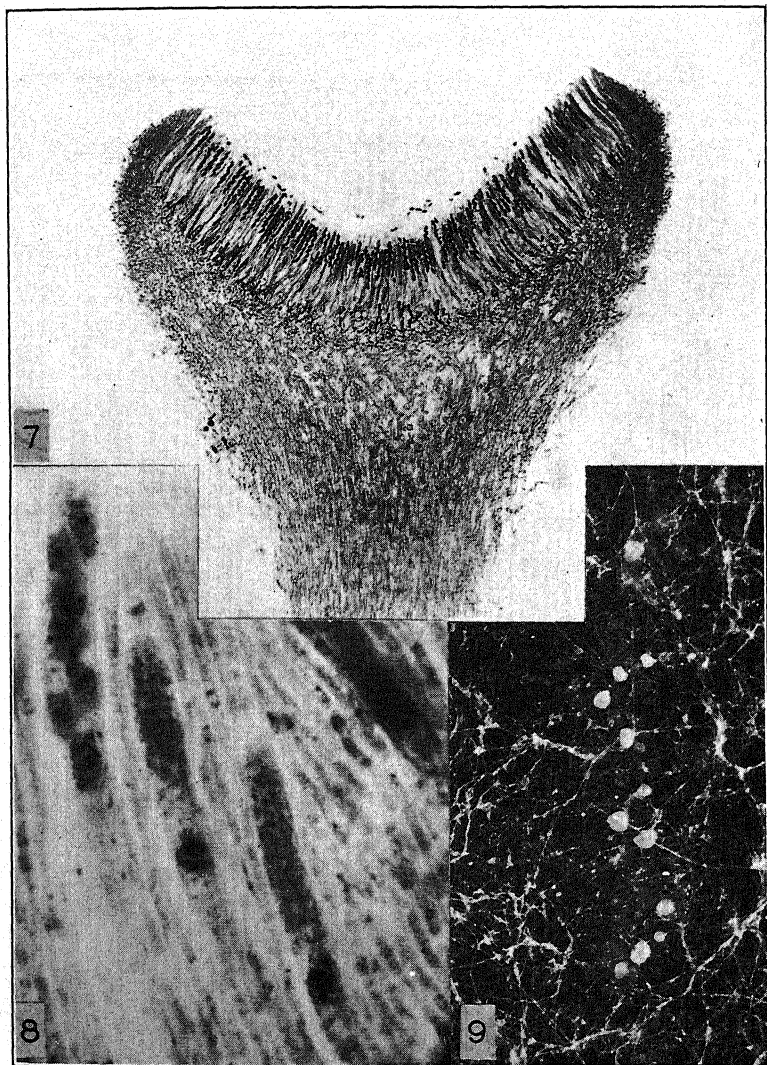


FIG. 6. *Sclerotinia convoluta*.

Ascospores from the apothecia were shot on potato-dextrose agar in Petri dishes. They germinated in 4 or 5 hours and 40 single-spore and several multiple-spore cultures were made. The former are identical with the original isolates. Conidiophores, conidia, and the characteristic convoluted sclerotial masses appeared on all of the cultures. A somewhat different appearance was noted in the multiple-spore cultures and it is of interest to speculate on the reason for this. In the original isolates which were obtained from plantings of conidia or sclerotia and those grown from single ascospores, both the aerial and sub-surface mycelium is white and the sclerotia are produced in abundance. The mass ascospore cultures are decidedly less vigorous, the

amount of aerial mycelium and the number and size of the sclerotia are greatly reduced, but the most striking differences are the brown color of the sub-surface mycelium and the early development of a great abundance of microconidia.

When certain pairs of the original isolates or those from single ascospores are grown on Petri dishes of potato-dextrose agar a



FIGS. 7-9. *Sclerotinia convoluta*.

marked brown line from 1 to 3 mm. across appears at the junction line and in and on this line large numbers of microconidial sporodochia appear (FIG. 9). The significance of this reaction is not understood, but it is apparently indicative of some form of antagonism between these thalli. In view of this, the peculiar characters exhibited by the multiple-spore cultures would seem to be the resultant of a great many reactions comparable to the junction line behavior with complete diffusion of the brown sub-surface mycelium and the presence of microconidia all over the surface of the slanted agar. Quite apart from the academic interest, this phenomenon indicates the necessity of using single ascospore cultures to describe cultural characters accurately.

Many of the single spore cultures have been grown on wheat, spermatized, and kept under conditions conducive to apothecial production. At the time of writing, abundant apothecial fundaments have developed from the sclerotia, but the apothecia are not yet mature.

EMENDED TECHNICAL DESCRIPTION

The development of apothecia by the fungus previously described as *Botrytis convoluta* Whetzel and Drayton, now makes it possible to complete the technical description, as follows:

Sclerotinia convoluta sp. nov.

Synonymy—*Botrytis convoluta* Whetz. & Drayton, Mycologia 24: 475. 1932.

Apothecia densely gregarious, arising from the sclerotial agglomerations (FIG. 2), infundibuliform to cyathiform becoming discoid, hymenium snuff brown, under side of cup and the stipe sayal brown (Ridgway), with a narrow, lighter band around the edge of the disc, sterile portion prosenchymatous with a definite hypothecium (FIG. 7); stipitate, varying in height from 3–6.25 mm., discs 2.5–4.0 mm. in diameter, stipes with more or less pronounced narrow, spiral, fibrillose ridges extending to the base of the cup (FIG. 4), the outer surface of the cup apparently glabrous, but on drying becoming subtomentose especially at the edge of the disc. Asci cylindrical, $150\text{--}195 \times 9\text{--}13 \mu$, the plug in the thickened apex staining blue with iodine (FIG. 6A). Ascospores 8, occupying $50\text{--}95 \mu$ of the ascus, uniseriate, ellipsoid, hyaline,

continuous, nonguttulate, uninucleate when first delimited (FIG. 8), at maturity with 2 or 4 nuclei, $11.7-19.5 \times 5.2-9.1 \mu$, average $14.87 \times 6.9 \mu$, mode $14.3-15.6 \times 6.5-7.8 \mu$. Paraphyses abundant, filiform, septate, hyaline, $2.5-3 \mu$ in diameter, occasionally wider near the apex.

Mycelium profusely branching, hyaline, becoming tan-colored with age at the surface of the substrate, multinucleate, $4.5-7.5 \mu$ in diameter.

Sclerotia shining black, convolute-agglomerated (FIG. 3), up to 18×16 mm. in size, frequently hollow in the centre, with a distinctly differentiated, black, pseudoparenchymatous rind, and a white medulla composed of more or less loosely intertwined hyphae, with slightly thickened walls, embedded in a colorless, homogeneous matrix.

Conidiophores brown, erect, fasciculate, branched at the apex, about 1 mm. tall, $9-12 \mu$ in diameter at the base, tapering toward the apex, arising from large, dark, thick-walled cells in the mycelium or from medullary cells just beneath the rind of the sclerotium (FIG. 3).

Conidia light brown, one-celled, smooth, ovate to slightly pyriform, borne in dense clusters on sterigmata produced from the swollen ampullae of the ultimate branchlets of the conidiophores (FIG. 6c); size variable, living spores from diseased rhizomes range from $7-18 \times 5.25-12.75 \mu$, mode $11.0-11.75 \times 9.0-9.75 \mu$, average $11.41 \times 9.25 \mu$ (FIG. 6D); somewhat smaller when produced on culture media. Cultures bearing conidia emit a sweetish aromatic odor.

Microconidia globose, $4-4.5 \mu$ in diameter, uninucleate, produced on a sporodochium made up of closely septate hyphae that give rise to numerous clusters of verticillately branched conidiophores ending in tapering, elongate, terminal cells (phialides) on which the microconidia are developed in vast numbers, embedded in a mucilaginous matrix which on drying, gives a waxy consistency to the whole sporodochium; produced on the mycelium, on the sclerotia, or by ascospores germinated in soil extract or water (FIG. 6B).

The cause of a necrotic disease of the garden iris, known as *Botrytis* rhizome rot. Sclerotia and conidia found in early spring (March and April); apothecia unknown in nature. Known from the United States, Canada, Germany, France, Holland, and England.

Apotheciis e sclerotiis orientibus, infundibuliformibus usque ad cyathiformibus, formam disci assumentibus, parte sterili prosenchymatosa, stipitata, 3-6.25 mm. alta; discis 2.5-4 mm. in diametro. Ascis cylindricis, $150-195 \times 9-13 \mu$. Ascosporis 8, uniseriatis, ellipsoideis, hyalinis, primo uninucleatis,

sed postea 2 aut 4 nucleos habentibus, $11.7-19.5 \times 5.2-9.1 \mu$, modulo $14.3-15.6 \times 6.5-7.8 \mu$.

Sclerotii atro-nitentibus convolutis agglutinatis, usque ad 18×16 mm.; conidiophoris brunneis, erectis, fasciculatis apice ramosis, circa 1 mm. altis, e cellulis callosis mycelii aut e sclerotii orientibus; conidiis pallide brunneis, ovatis vel pyriformibus, $7-18 \mu$ longis, $5.25-12.75 \mu$ in diametro; microconidiis globosis, $4-4.5 \mu$ in diametro.

In hortis irides necat.

Type specimens of the conidial stage deposited in the Plant Pathological Herbarium, Cornell University, Ithaca, N. Y., No. 12615. Type specimens of the apothecial stage deposited in the Herbarium, Division of Botany, Central Experimental Farm, Ottawa, Ont., No. 3010, the Plant Pathological Herbarium, Cornell University, Ithaca, N. Y., No. 25282. Duplicate material from the same cultures also deposited in the Farlow Herbarium, Harvard University, Cambridge, Mass., The New York Botanical Garden, New York, N. Y., the Royal Botanic Gardens, Kew, Surrey, England, the Pathological and Mycological Collections, Bureau of Plant Industry, Washington, D. C., and the Department of Botany, University of Toronto, Toronto, Ont.

SUMMARY

Another instance of a genetic connection between species of the genera *Botrytis* and *Sclerotinia* is recorded. The fungus is one causing the *Botrytis* rhizome rot of garden iris described by Whetzel and Drayton and named *Botrytis convoluta*.

Under carefully controlled cultural conditions, combined with the use of microconidia for spermatization, the convoluted sclerotial masses of this fungus have developed apothecia of the *Sclerotinia* type. The connection of this ascigerous stage with the conidiophores and conidia of the imperfect stage is established.

The new binomial *Sclerotinia convoluta* is proposed and a technical description is given.

ACKNOWLEDGMENTS

In the preparation of the histological material and the taking of some of the photographs, the assistance of Dr. R. E. Fitzpatrick,

formerly graduate assistant in this laboratory, is gratefully acknowledged. The rest of the photographs were taken by Mr. A. J. Hicks and Dr. J. W. Groves. The author is also indebted to Professor H. H. Whetzel for his unfailing interest and co-operation during the course of this investigation.

DIVISION OF BOTANY,
CENTRAL EXPERIMENTAL FARM,
OTTAWA, CANADA

LITERATURE CITED

- Bary, A. de. Morphologie und Physiologie der Pilze, Flechten, und Myxomyceten. Hofmeister's Handb. Physiol. Bot. 2: 1866.
- . Vergleichende Morphologie und Biologie der Pilze, Mycetozen, und Bacterien. 558 pp. Leipzig, 1884.
- Beyma Thoe Kingma, van F. H. Ueber eine neue *Sclerotinia*—Art auf Porreesamen (*Allium Porrum*), *Sclerotinia Porri*. Meded. Phytopath. Lab. Willie Commelin Scholten 10: 43-46. 1927.
- Drayton, F. L. The sexual mechanism of *Sclerotinia Gladioli*. Mycologia 26: 46-72. 1934a.
- . The gladiolus dry rot caused by *Sclerotinia Gladioli* (Massey) n. comb. Phytopath. 24: 397-404. 1934b.
- Godfrey, George H. *Sclerotinia Ricini* n. sp. parasitic on the castor bean (*Ricinus communis*). Phytopath. 9: 565-567. 1919.
- . Gray mold of castor bean. Jour. Agr. Res. 23: 679-715. 1923.
- Ludwig, F. *Sclerotinia Galanthi*. Lehrb. Nied. Kryptog. 355. 1892.
- Seaver, Fred J. *Botrytis* and *Sclerotinia*. Science 46: 163. 1917.
- & W. T. Horne. Life history studies in *Sclerotinia*. Mem. Torrey Club 17: 202-206. 1918.
- Whetzel, H. H. & F. L. Drayton. A new species of *Botrytis* on rhizomatous iris. Mycologia 24: 469-476. 1932.

EXPLANATION OF FIGURES

Fig. 1. A preparation dish with sclerotial groups bearing apothecia. Natural size.

Fig. 2. Two of the above groups of apothecia ($\times 6$).

Fig. 3. A convoluted sclerotial mass bearing conidiophores and conidia ($\times 6$).

Fig. 4. A side view of a group of apothecia showing the spiral fibrillose markings on the stipes ($\times 8$).

Fig. 5. Four groups of sclerotia bearing conidiophores and apothecia ($\times 5$).

Fig. 6. A, Asci, ascospores, and paraphyses. B, An ascospore germinating in soil extract and producing microconidia. C, Conidiophore with immature conidia. D, Mature conidia.

Fig. 7. A longitudinal section of an apothecium stained with gentian violet and safranin. Note the young and mature asci, the hypothecium, and the prosenchymatous context ($\times 40$).

Fig. 8. Portion of a longitudinal section of an apothecium. One ascus shows the uninucleated condition of the ascospores when first cut out, and each of the other two asci with a fusion nucleus ($\times 850$).

Fig. 9. Portion of the junction line of a culture from paired isolates, showing the development of surface and sub-surface microconidial sporodochia ($\times 6$).

MIMICRY IN HYPOXYLON

WILLIAM W. DIEHL

(WITH 3 FIGURES)

The accompanying illustration (FIG. 1-3) shows an abortive development of *Hypoxylon marginatum* (Schw.) Berk., accompanying the characteristic plant. Each abnormal stromatic unit possesses most strikingly, but entirely superficially, the appearance of *Camillea Sagraeana* (Mont.) Berk. & Curt. These abnormal stromata are sterile and without any trace of perithecia. No parasite was definitely evident, and no explanation is suggested for this condition. The specimen was found by Dr. C. L. Shear near Falls Church, Va., Oct. 8, 1925.

Two similar specimens, gathered in 1928 by R. Kent Beattie (nos. 62 and 67) at Kuraru, in Taiwan (Formosa), have lately been available for comparison. Most of the stromata in this material show the *Camillea*-like appearance as in the specimens from Virginia. A few, however, are more nearly normal, although without asci or spores. These resemble *Hypoxylon cohaerens* Fries, to which species these Formosan specimens are probably referable.

The resemblance to a species of the characteristically tropical genus *Camillea* shown by these aberrant specimens of two temperate-zone species of *Hypoxylon* is so striking that one familiar with both genera could readily be deceived by superficial examination only. Although they are teratological manifestations of two different species of *Hypoxylon* it is remarkable that they simulate a distinctive species of the related genus *Camillea*.

To call such a resemblance "mimicry," although the term has been practically unused in mycology,¹ is to be condoned perhaps by its frequent and time-honored usage for such a condition in organisms which possess comparable resemblances no more expressive of volition than in fungi.

DIVISION OF MYCOLOGY AND DISEASE SURVEY,
BUREAU OF PLANT INDUSTRY,
WASHINGTON, D. C.

¹ Cooke, M. C. Mimicry in fungi. *Grevillea* 9: 151-153. June 1881.

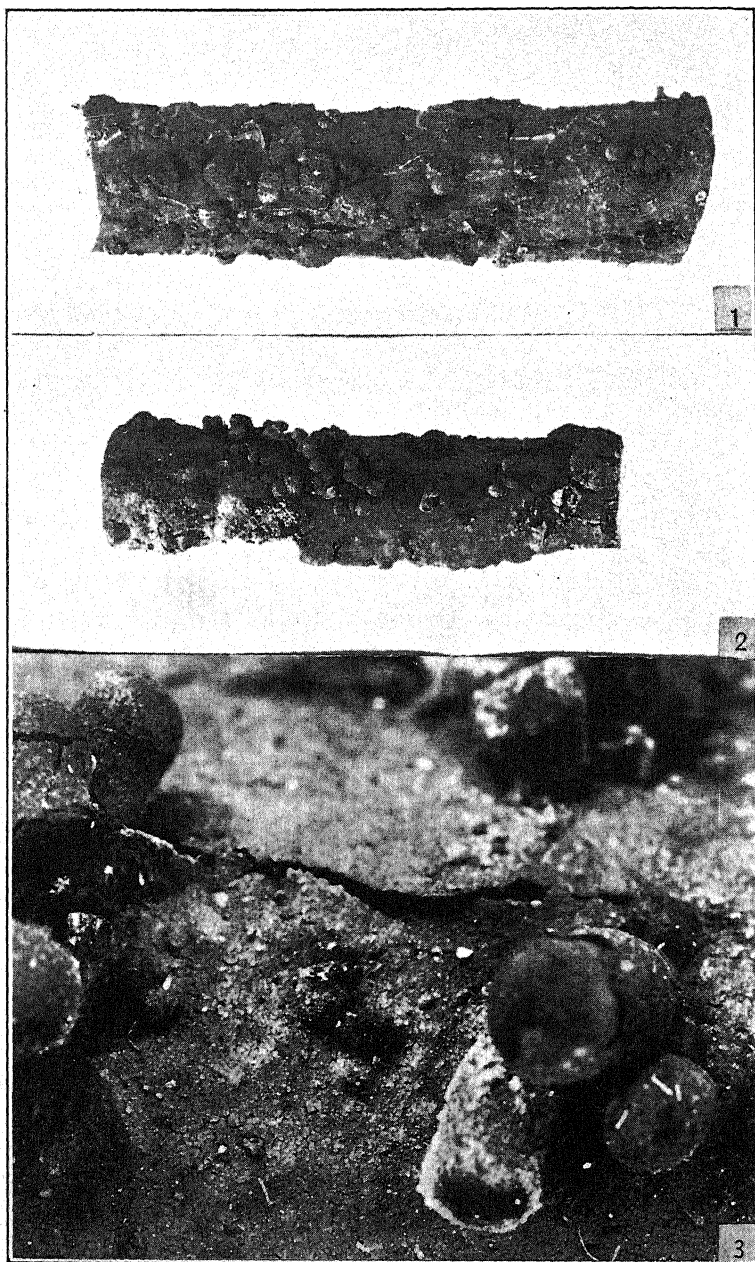


FIG. 1, chiefly normal stromata ($\times 1$); 2, abnormal and normal stromata ($\times 1$); 3, abnormal stromata ($\times 10$). Photographs by Mr. M. L. S. Foubert.

A NEW SPECIES OF DOTHIORELLA CAUSING DIE-BACK OF ELM

A. F. VERRALL AND CURTIS MAY¹

(WITH 6 FIGURES)

Dothiorella Ulmi is the pycnidial form of the fungus previously reported as causing the disease commonly known as the *Cephalosporium* die-back of elm. This disease was observed on American elm (*Ulmus americana* L.) in Minnesota in 1929 and the causal organism tentatively placed in the Sphaeropsidales because of pycnidia formed on malt agar (5). The same organism was isolated from specimens collected in 1930 in the midwestern and eastern states and reported as *Cephalosporium* sp. (3). The fungus has also been reported from Nebraska (2). The disease of American elm noted from Connecticut in 1930 (1) has subsequently been found by a comparison of cultures to be caused by the same organism.

The *Cephalosporium* stage of the fungus was isolated from diseased elms. Transfers were made from these cultures to sterilized elm twigs upon which pycnidia developed abundantly. Similar pycnidia have been found on naturally diseased elm. Single-spore isolations from pycnidia on specimens collected in New Jersey and Virginia produced the typical *Cephalosporium* stage on agar. Trees inoculated with single-spore isolates developed typical symptoms of the disease and both stages of the fungus were recovered from them.

The characteristics of the pycnidial stage of the fungus place it in the genus *Dothiorella* in the broad sense as used by Saccardo

¹ Respectively, Assistant Pathologist, Division of Forest Pathology, and Emergency Conservation Work, and Senior Pathologist, Division of Forest Pathology, Bureau of Plant Industry, U. S. Department of Agriculture.

Acknowledgment is given R. U. Swingle and L. M. Fenner of the Division of Forest Pathology, C. L. Shear of the Division of Mycology and Disease Survey, U. S. Department of Agriculture, and the Staff of The New York Botanical Gardens for assistance, criticisms, and use of herbarium material.

(4). A search of literature and an examination of available herbarium specimens and a comparison of cultures of various species of *Cephalosporium* failed to disclose any *Dothiorella* or *Cephalosporium* identical with the die-back organism. The fungus is here described as a new species of *Dothiorella*.

***Dothiorella Ulmi* sp. nov.**

Stroma basal (FIG. 1), irregularly circular to elongate, 100–385 μ across, subepidermal, early erumpent; pycnidia partially imbedded in the stroma (FIG. 1, 2), in groups of 2–12, occasionally single, black, at first solid and subsclerotoid, and finally with a more or less subcoriaceous wall, glabrous, globose to irregular, 63–161 μ in diameter, occasionally reduced to irregular chambers (FIG. 4); ostioles non-papillate, 7–13 μ in diameter; conidia (FIG. 3) 1-celled, hyaline, elongate, rounded at both ends, straight or occasionally slightly curved, $2.9\text{--}5.4 \times 0.5\text{--}1.0 \mu$ (av. $3.6\text{--}0.8 \mu$); conidiophores absent, the conidia being histogenic.

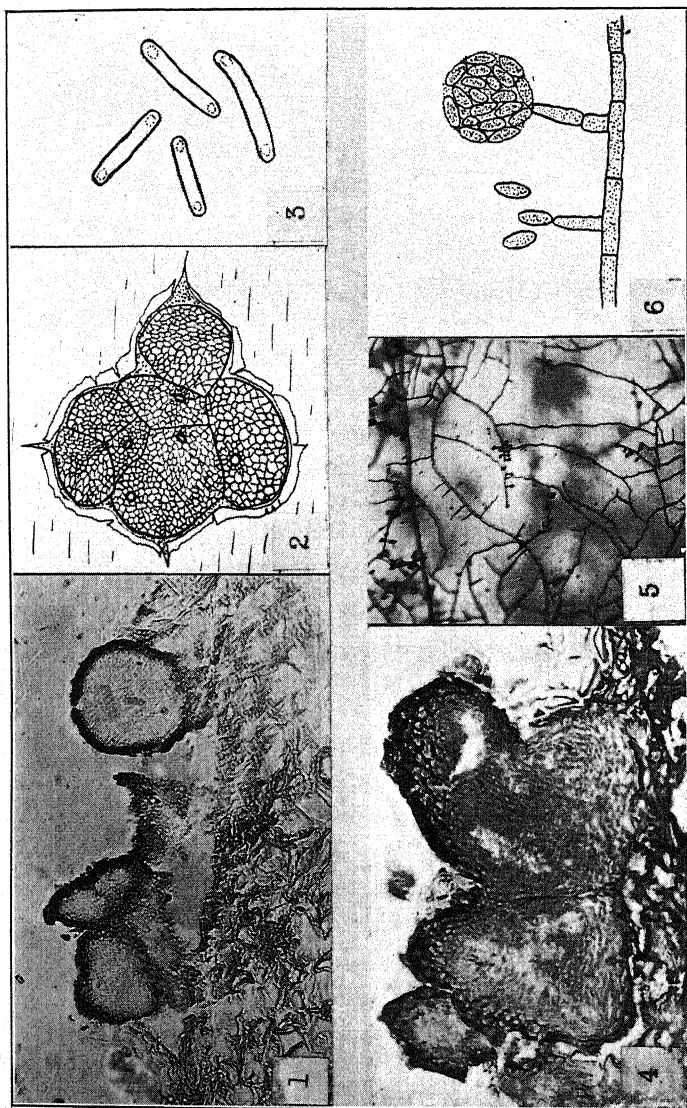
Stroma basilare, irregulariter orbiculatum vel elongatum, in diametro 100–385 μ , subepidermale, erumpente; pycnidia in stromate subimmersa, 2–12 aggregata, aliquando singularia, atra, glabrata, globosa vel irregularia, in diametro 63–161 μ , aliquando ad loculos irregulares reducta; ostiolo epapillati, in diametro 7–13 μ ; conidia 1-cellularia, hyalina, elongata, utrinque rotundata, recta vel nonnumquam leniter curvata, $2.9\text{--}5.4 \times 0.5\text{--}1.0 \mu$ (av. $3.6 \times 0.8 \mu$); conidiophori nulli.²

This species is characterized by inconspicuous pycnidial groups, small pycnidia, and by small, histogenic spores. Type material has been deposited in the mycological collections of the Bureau of Plant Industry, U. S. Department of Agriculture, Washington, D. C., under No. 70804.

Occurring on elm (*Ulmus americana* L. and *U. fulva* Michx.) as a cause of a prevalent die-back characterized by brownish discoloration of the cambial region and outer layers of wood, wilting of leaves, and cankers, at first reddish brown, then becoming darker. Pycnidia develop sparsely on newly formed cankers on twigs and small branches and are often associated with *Sphaeropsis*, *Phoma*, *Cytospora*, and other fungi as the cankers age. Pycnidia have been found on elm collected in Virginia, Connecticut, Ohio, New Jersey, and Oklahoma.

The die-back fungus has been isolated from 42 per cent of the

² Latin description by R. Kent Beattie, Division of Forest Path., U. S. Department of Agriculture.



FIGS. 1-6. *Dothiorella Ulmi*.

57,547 specimens of elm submitted from 1930 to 1935 as suspected of having the Dutch elm disease. Most of these specimens were supposedly American elm but a few from which the die-back organism was isolated were slippery elm (*U. fulva* Michx.). The die-back fungus was isolated from specimens collected in 28 states, the District of Columbia, and Canada. The disease is common where elms occur from Virginia to Oklahoma northwards to Canada. A few infected specimens have been received from Colorado and Montana.

Cultures of *D. Ulmi* on malt or potato-dextrose agar are very variable in color and rate of growth. Usually cultures are brown, slow growing, with a filamentose margin, frequently forming elongate yellow crystals in the agar below the mat, and producing a sweet aromatic odor. *Cephalosporium* heads (FIG. 5, 6) develop in isolated groups on the mycelium. The conidiophores are relatively short compared with the described species of *Cephalosporium*, being $0.7\text{--}20\ \mu$ (av. $5.6\ \mu$) in length; straight, mostly unbranched. Conidia are hyaline, 1-celled, elliptic, $4.5 \times 1.9\ \mu$. Pycnidia sometimes develop singly or in small groups in agar. The pycnidiospores are identical to these formed in nature.

LITERATURE CITED

1. Anon. Report of the Director for the year ending Oct. 31, 1930. Elm disease under investigation. Conn. Agric. Exper. Sta. Bull. 322: 119. 1930.
2. Goss, R. W. & Paul R. Frink. *Cephalosporium* wilt and die-back of the white elm. Agric. Exper. Sta., Univ. of Neb. Research Bull. 70. 1934.
3. May, Curtis. A new elm disease. Science, n. s. 74: 437. 1931.
4. Saccardo, P. A. Sylloge fungorum. 3: 335 et seq. 1884.
5. Verrall, A. F. Die-back of elm in Minnesota. Phytopath. 20: 1004-1005. 1930.

EXPLANATION OF FIGURES

Fig. 1-6. *Dothiorella Ulmi*: 1. Section through stroma and pycnidia in bark. 130 X. 2. Camera lucida drawing of pycnidial group showing ostioles and arrangement on stroma. 100 X. 3. Camera lucida drawing of spores from a pycnidium. 3900 X. 4. Section through pycnidia showing disappearance of side walls forming an irregular chamber. The pycnidia are filled with the pseudotissue from which spores are formed. 250 X. 5. Mycelium in culture showing aggregations of *Cephalosporium* heads. 100 X. 6. Camera lucida drawing of *Cephalosporium* heads in culture. 1000 X.

A NEW SPECIES OF TUBERACEAE FOR AMERICA

CLOYD BURNLEY STIFLER

On August 26, 1930, specimens of *Hydnотria carnea* Corda were found by the writer, half-buried in the mud, in a path beside the Lower Tunkhanna, a trout stream near Fern Ridge in the Pocono Mountains, Pennsylvania.

Two small potato-like fruit bodies were collected and preserved in 70 per cent alcohol containing a little glycerine.

When examined microscopically they proved to be hypogaeous ascomycetes and were identified by the writer as either *Hydnотria Tulasnei* Berk. & Br., or *Hydnотria carnea* Corda according to the descriptions in Hesse's *Die Hypogaeen Deutschlands*.

The fruit bodies were irregularly globose and the size of hickory nuts (2.7×2 cm. and 2.3×1.7 cm.). They are nearly smooth on the exterior surface with a few small fissures or depressions. The color is between flesh and a rusty brown. To the unaided eye there is no distinct peridium. Any slight floccosity may have been lost when the mud was removed. Small canals present in the gleba are lined with the hymenium. The asci are generally long stiped and cylindrical although some are clavate. In size they average $220\text{--}34\ \mu$ (in upper portion).

The spores are usually uniseriate but occasionally biseriate near the middle of the ascus which then appears to bulge on one side at that point.

The number of spores varies. Usually 8 are present but in some cases fewer than that. They are irregularly globose. The exposure is composed of thick blunt warts and varies in color from yellow to dark brown. The size varies from $31\text{--}36 \times 34\text{--}37\ \mu$ including the warts. The exospore varies from 2.5 to $7.7\ \mu$ in thickness due to these warts.

A few asci lie at the base of the others and are perpendicular to them. The paraphyses are colorless, irregularly cylindrical, septate, much longer than the asci and about $6.8\ \mu$ in diameter.

The banks along the Little Tunkhanna are suitable for the

growth of various fungi. It bordered by rhododendron. The trees are beech, grey birch, maple and hemlock. The ground cover is composed of mosses, arbutus, partridge berry and lichens, and in a few pots some grasses.

Hesse states that the species *Hydnotria carnea* occurs in Europe in sheep pastures, under trees, where sheep find shade at midday and where their excrement, trampled into the soil yields a rich compost, and that when ripe the fruit bodies work up toward the surface until they are partly exposed.

There are no sheep in this locality but deer are plentiful and deer dung may have been trampled into the soil, however, there is no evidence of this.

The place where the fruit bodies were found has been visited each summer since 1930 but no more specimens have appeared.

A section of the largest fruit body was sent to Dr. Fred J. Seaver who agreed that the specimen was a *Hydnotria*, probably *Tulasnei*, and suggested that it was new to America and should be referred to Dr. Helen M. Gilkey for identification.

After examining it Dr. Gilkey wrote that there had been some confusion between the two species, that Tulasne considered *Hydnotria carnea* a synonym for *H. Tulasnei*, and Dr. Ed. Fischer was undecided as to whether they might be two varieties of one species—*Hydnotria Tulasnei*—and stated, "Your specimen is characterized by a cylindrical rather than club shaped ascus. The gleba is not as dark brown as it is sometimes figured, but that may be due to the fact that the material is not completely mature though enough spores are ripe to leave no question concerning their ultimate form. I am very pleased at this first record of this species in America."

A post script written after she had read further notes by Dr. Ed. Fischer, however, states, "Your specimen is *Hydnotria carnea* Corda. At any rate this is the first report of it from America to my knowledge."

A letter just now received, January 1937, from Dr. John A. Stevenson states that, "As far as Miss Cash and I have been able to determine *Hydnotria carnea* Corda has not been found in this country."

SPORULATION OF THE PHIALOPHORA TYPE IN HORMODENDRUM

C. W. EMMONS AND A. L. CARRIÓN

(WITH 6 FIGURES)

Hormodendrum is an important genus of the Fungi Imperfecti. Its species have a wide geographical distribution and are commonly present in soil and decaying vegetation. Because of the ubiquity of its wind-blown spores it is a familiar "culture weed" of the laboratory. Most species of the genus are saprophytes, but at least two are facultative pathogens of man and there cause a skin disease known as "dermatitis verrucosa" (chromoblastomycosis). This disease apparently is not contagious, and the evidence at hand indicates that the fungus is a wound parasite capable of growing in animal tissue only after its introduction upon some foreign body such as a thorn. In this respect it is like some of the other mycotic diseases in which the parasitic agent requires certain special, and in some cases, unknown conditions before it becomes pathogenic, but once established in the human body, it is extremely difficult to dislodge.

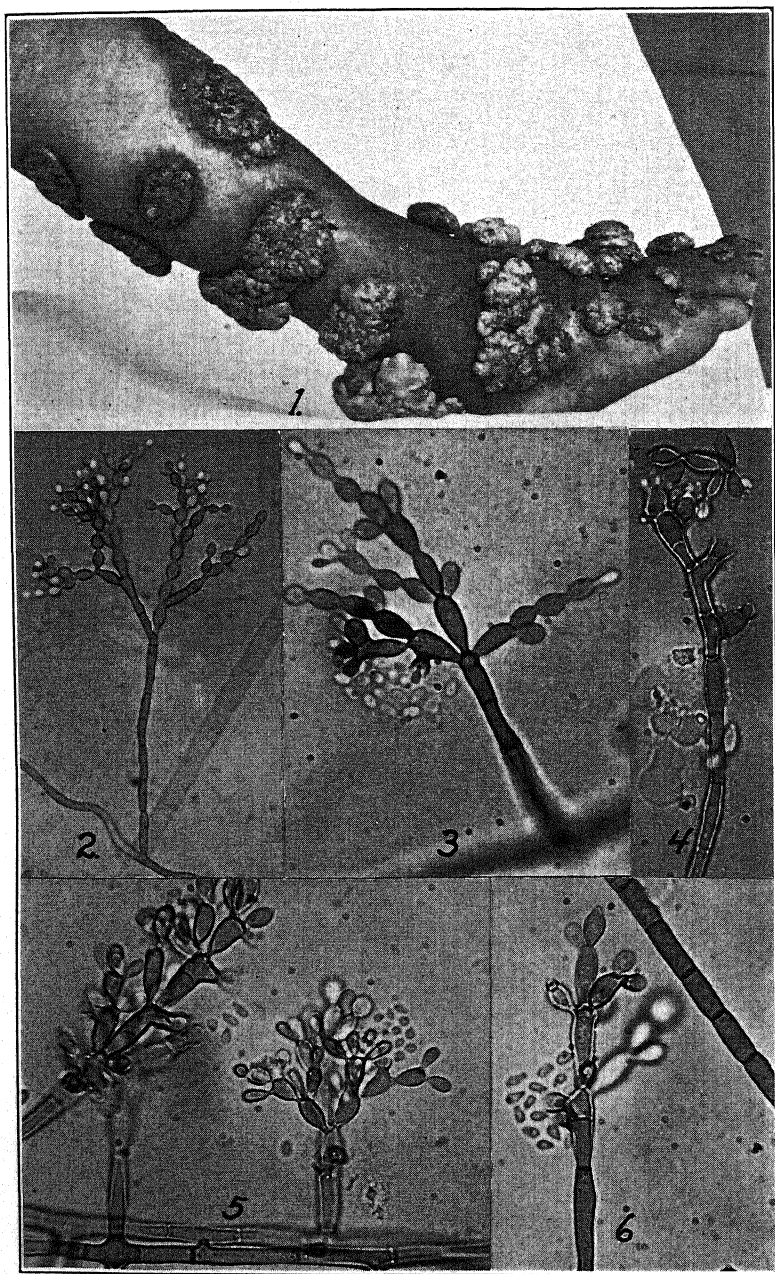
Dermatitis verrucosa occurs chiefly in the tropics, and more rarely in temperate climates. Three cases have been reported from the United States. The disease is generally characterized in man by the formation on an extremity, usually a leg, of warty or cauliflower-like outgrowths of the skin (FIG. 1). In some cases it has been possible to obtain from the patient a history of some slight injury to the foot, followed by the slow appearance and development of a small initial lesion. By slow extension of this primary lesion the entire lower leg may become involved. Extension of the pathologic process is not rapid, and a duration of several years, without metastatic spread, and without serious interference with the activities of the patient is the rule. Sections of the infected tissue show the fungus present in the form of subspherical pigmented cells often occurring in pairs or short chains. In spite of

its benign course, the infection is very difficult to eradicate by the methods of treatment now in general use.

It should be stated that notwithstanding the similarities in clinical aspect of the reported cases of "dermatitis verrucosa" there is some evidence that deviations from the usual clinical type may occur. However that may be, we do know that the disease may be caused by any one of three species of related fungi. The first reported case, which was from Boston, was caused by *Phialophora verrucosa*,⁸ studied and named by Thaxter. The most common cause of the disease in Puerto Rico and Brazil is *Hormodendrum pedrosoi*⁴ Brumpt. *H. compactum*^{1,2} Carrión has been isolated from a single case in Puerto Rico. *H. Langeroni*⁶ was the etiologic agent of a different disease. Recently Moore,⁹ without any accompanying definitions, proposed two new generic names for the fungi of "dermatitis verrucosa," and one new species. He very kindly sent us a culture of the latter. The fungus which he named as a new species, *Phialoconidiophora guggenheimia*, is clearly a typical strain of *H. pedrosoi*, and the new name is to be added to the already too long synonymy of that species.

Phialophora verrucosa and *Hormodendrum pedrosoi* have long been known as the commonest causes of the disease. *Phialophora verrucosa* is characterized by the formation of spores in the mouth of a flask-shaped conidiophore. This may be looked upon as a semi-endogenous type of sporulation. The spores are budded out serially from the base of the cup which terminates this conidiophore and they collect in a droplet at the mouth of the cup. The conidiophore is not capable of further growth, although in abnormal cases sporulation may be interrupted by the formation of a cell, which, instead of being discharged as a spore, remains attached in the base of the flaring cup which forms the mouth of the conidiophore. This cell in turn bursts at the tip, the cell wall at the point of rupture grows into a cup, and this secondary conidiophore then

FIG. 1, skin lesions in a case of *Dermatitis verrucosa* caused by *Hormodendrum pedrosoi*; 2, a well developed conidiophore of the *Hormodendrum* type in *H. pedrosoi* (\times about 250); 3, a conidiophore of *H. pedrosoi* in which one cell in the spore chain has produced a *Phialophora*-like cup and spores (\times 900); 4, sporulation of the *Phialophora* type in *H. pedrosoi* (\times 900); 5 and 6, sporulation of the reduced *Hormodendrum* type closely associated with sporulation of the *Phialophora* type in *H. pedrosoi* (\times 900).



FIGS. 1-6.

carries on spore production in the usual manner. A few conidiophores open by more than one mouth.

In contrast to the above, *Hormodendrum* is characterized by a type of exogenous spore formation in which the conidia are borne in branching chains which arise from somewhat specialized conidiophores (FIG. 2). Sporulation takes place by a process of budding at the tips of the conidial chains, and the chains are dendroidal or branched because some of the spores bud at more than one point. The mature spore head therefore assumes a tree-like form in which the youngest spores are at the tips of the branches, and, given proper conditions of youth and nutrition, are capable of the production of additional secondary spores. This process may be indefinitely repeated.

Despite their widely separated positions in the Saccardo classification of the Fungi Imperfecti, a genetic relationship between *Phialophora* and *Hormodendrum pedrosoi* has long been suspected. Weidman¹⁰ suggested that they might be different phases of the same fungus. Proof of such a relationship, however, had not been given. It was therefore gratifying to be able to demonstrate, during a critical comparative study of strains isolated in Puerto Rico and in other parts of the world, that the type of sporulation characteristic of *Phialophora* does actually occur in *Hormodendrum*. This fact was demonstrated for all our collected strains of *H. pedrosoi*, for *H. compactum*, and for a saprophytic strain of *Hormodendrum* isolated in the laboratory. This discovery was reported in 1935 in a preliminary paper³ in the Puerto Rico Journal of Public Health and Tropical Medicine, and in later papers^{2, 4, 5} in the same journal. Conant⁷ subsequently found *Phialophora* sporulation in the strain of *H. pedrosoi* isolated in North Carolina, and Moore⁹ observed it in the strain he reported.

Sporulation in the species *Hormodendrum pedrosoi* is somewhat reduced in comparison with that of saprophytic species of the genus. Most of the spores are produced either in branching conidial chains which are short, but are otherwise characteristic of *Hormodendrum*, or upon conidiophores of a type somewhat resembling those of *Acrotheca*. Conidiophores of the *Phialophora* type occur only rarely, but when found they are well developed and are similar in every way to those of *Phialophora verrucosa* (FIGS.

3-6). Besides their rarity they are somewhat more variable in size and shape than the corresponding structures in *Phialophora*, and they appear to be less prolific. That they are homologous structures in the several species under consideration seems evident, however. In *Hormodendrum* they can be conveniently demonstrated upon cornmeal agar slide cultures. Conidiophores of this type may be grouped together on certain hyphae (FIG. 4), they may be solitary, or they may be formed in very close proximity to the *Hormodendrum* type of conidiophore. The closest possible association of the two types of sporulation occurs when, as sometimes happens, a *Hormodendrum* spore in an otherwise normal spore head becomes transformed by the rupture of the end wall into a conidiophore of the *Phialophora* type (FIGS. 3, 5, 6). This has been seen more frequently in *H. compactum* than in other species.

Observations of stages in the transformation of a *Hormodendrum* spore directly into a conidiophore of the *Phialophora* type gives us some insight into the probable relationship between these two divergent methods of sporulation. We may assume that a given cell appearing as a side branch on the mycelium of *H. pedrosoi*, for example, has the potentialities of either a *Hormodendrum* or a *Phialophora* conidiophore. The predominant tendency is toward the former, but unknown forces may tip the scale toward the latter. When a *Phialophora* conidiophore appears as an integral part of a *Hormodendrum* spore head it means that this plasticity has been retained to a period in development long after morphological differentiation has been well established.

The actual changes which bring about this transformation seem to be as follows. The wall at the tip of one of the spores in an otherwise normal spore head ruptures at the point where it would normally produce a secondary spore. A plasma membrane and a secondary wall retain the protoplasm of this cell, and the broken portions of the ruptured wall develop into a cup, characteristic of *Phialophora*, from the base of which the spores are budded out. It may well be that *Phialophora verrucosa* is a mutant which arose from some species of *Hormodendrum* when this tendency to cup formation became dominant over secondary budding.

The possibility that these anomalous spores, appearing infrequently on the mycelium of *Hormodendrum*, are not conidia but are actually spermatia, is obviously to be considered. The bottle-shaped sporophore which bears them undoubtedly resembles a spermatophore. The spores, which are about $1.5-2 \times 2-3 \mu$, might well be spermatia. In view, however, of our belief that both sporophore and spore are homologous with the corresponding structures which constitute the only known method of reproduction in *Phialophora*, and in the absence of any demonstrated spermatial function for these spores, we prefer to look upon them as conidia. The spores of *Phialophora* germinate readily by a sort of pseudo-budding, but this, as Dodge has shown for other fungi, can not be taken as proof of a non-spermatial character. If they be spermatia, however, they now function perfectly in *Phialophora* as conidia.

If, as certainly seems possible, the spores of the *Phialophora* type developing infrequently in cultures of *Hormodendrum pedrosoi* and *H. compactum* are actually spermatia, it is to be hoped that their discovery foreshadows the demonstration of an ascomycetous phase of these fungi. In view of this and of other considerations it is deemed advisable to retain for these fungi the generic name *Hormodendrum* under which they were first described, rather than transfer them to *Cladosporium*.

The production of two types of conidia by one fungus is by no means unknown to mycologists. In this case, however, sporulation of a semi-endogenous type and exogenous sporulation, occurring either on different parts of the same mycelium or in such close association that one is derived directly from the other seems noteworthy. This association seems particularly significant in this case because it indicates a relationship, previously only suspected, between two etiologic agents of one disease.

NATIONAL INSTITUTE OF HEALTH,
WASHINGTON, D. C.,
AND
SCHOOL OF TROPICAL MEDICINE,
SAN JUAN, PUERTO RICO

REFERENCES

1. Carrión, A. L. Chromoblastomycosis. Preliminary report on a new clinical type of the disease caused by *Hormodendrum compactum* nov. sp. Puerto Rico Jour. Public Health and Trop. Med. 10 (4): 543-545. 1935.
2. —. Chromoblastomycosis. A new clinical type caused by *Hormodendrum compactum*. Puerto Rico Jour. Public Health and Trop. Med. 11 (4): 663-702. 1936.
3. Carrión, A. L. & Emmons, C. W. A spore form common to three etiologic agents of chromoblastomycosis. Puerto Rico Jour. Public Health and Trop. Med. 11 (1): 114-115. 1935.
4. Emmons, C. W. & Carrión, A. L. *Hormodendrum pedrosoi*; an etiologic agent in chromoblastomycosis. Puerto Rico Jour. Public Health and Trop. Med. 11 (4): 639-650. 1936.
5. —. The Phialophora type of sporulation in *Hormodendrum pedrosoi* and *Hormodendrum compactum*. Puerto Rico Jour. Public Health and Trop. Med. 11 (4): 703-710. 1936.
6. Fonseca, Arêa Leão & Penido, Nogueiro. Mycose de tipo ulceronodular, etc. Sciencia Medica 5: 563-580. 1927.
7. Martín, Donald S., Baker, Roger D. & Conant, Norman F. A case of verrucous dermatitis caused by *Hormodendrum pedrosoi* (chromoblastomycosis) in North Carolina. Am. Jour. Trop. Med. 16 (5): 593-619. 1936.
8. Medlar, E. M. A new fungus *Phialophora verrucosa* pathogenic for man. Mycologia 7: 200-203. 1915.
9. Moore, Morris. The organisms of chromomycosis of North and South America. Science 83 (2164): 603-604. 1936.
10. Wilson, S. J., Hulsey, S. & Weidman, F. D. Chromoblastomycosis in Texas. Arch. Derm. and Syph. 27: 107-120. 1933.

PHOTOGRAPHS AND DESCRIPTIONS OF CUP-FUNGI—XXVII. PEZICULA ON CORNUS¹

FRED J. SEAVER

(WITH 2 FIGURES)

The writer recently received specimens of *Pezicula* on *Cornus* collected at East Hampton, New York, which was at first thought to be *Pezicula Corni* Petrak. However, critical study showed it to be quite different in spore characters from that species. Since the New York species varies greatly from *Pezicula Corni*, which has been collected from California to Oregon, we take this opportunity to describe it as a new species, publishing illustrations of both in order to show the differences.

Both of these species are associated with a *Myxosporium* which appears to be respectively their conidial stages. Attempts to culture the material from New York were unsuccessful, owing to the fact that the spores had apparently been killed by the disinfectant. The New York material was sent to the writer by R. P. White who has done some culture work which indicates that the *Myxosporium* is the conidial stage of the new species. The writer will be glad to receive any other material of this genus from this host.

Pezicula Corni Petr. Ann. Myc. 20: 197. 1922.

?*Dermatea Corni* Phill. & Hark. Grevillea 13: 22. 1884.

Pezicula rhabarbina f. *Corni* Ellis in Herb.

Apothecia solitary or cespitose, at first rounded, becoming expanded and subdiscoïd, with a mealy brown covering, reaching a diameter of about .5–1 mm.; hymenium plane or nearly so, yellowish to dark brownish-black; asci clavate, reaching a length of 120 μ and a diameter of 27 μ , 8-spored; spores ellipsoid irregularly

¹ This paper is preliminary to a monograph of North American Cup-fungi (inoperculates), a companion volume to North American Cup-fungi (operculates), which was published by the author and issued in December, 1928.

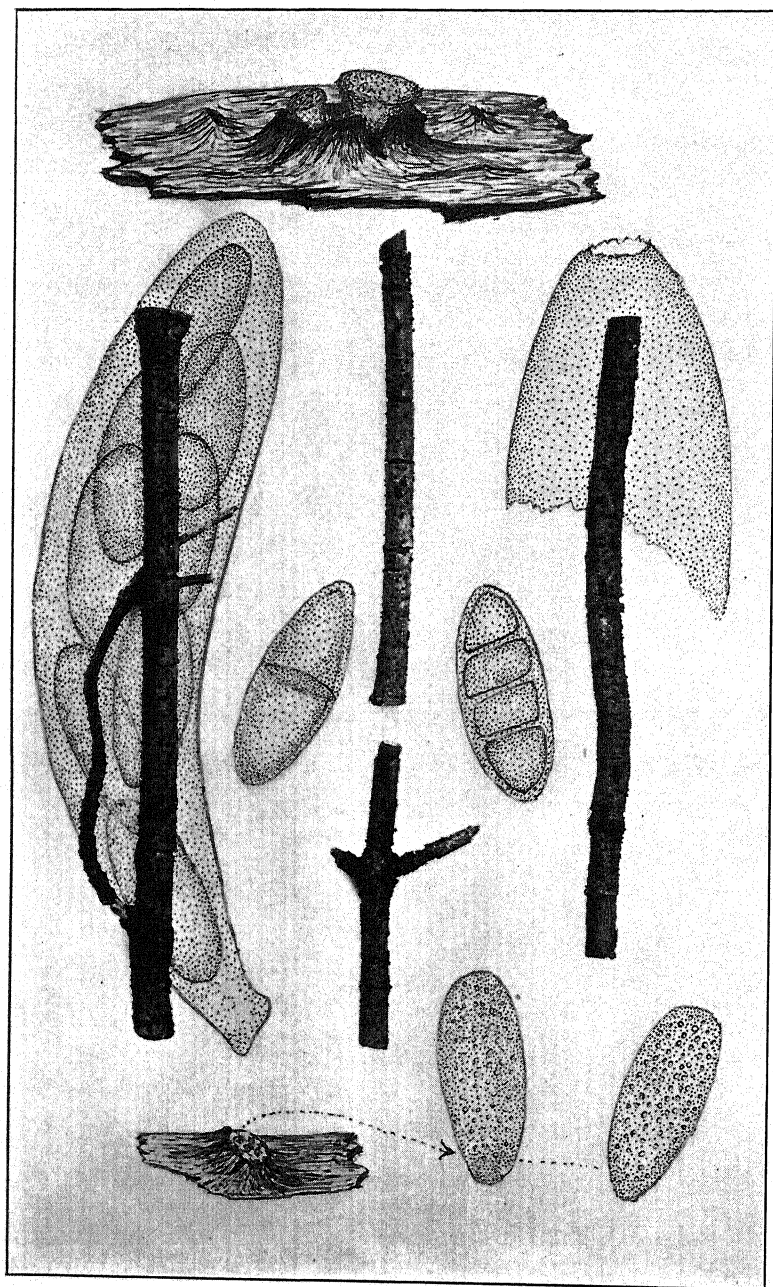


FIG. 1. *Pezicula Corni*.

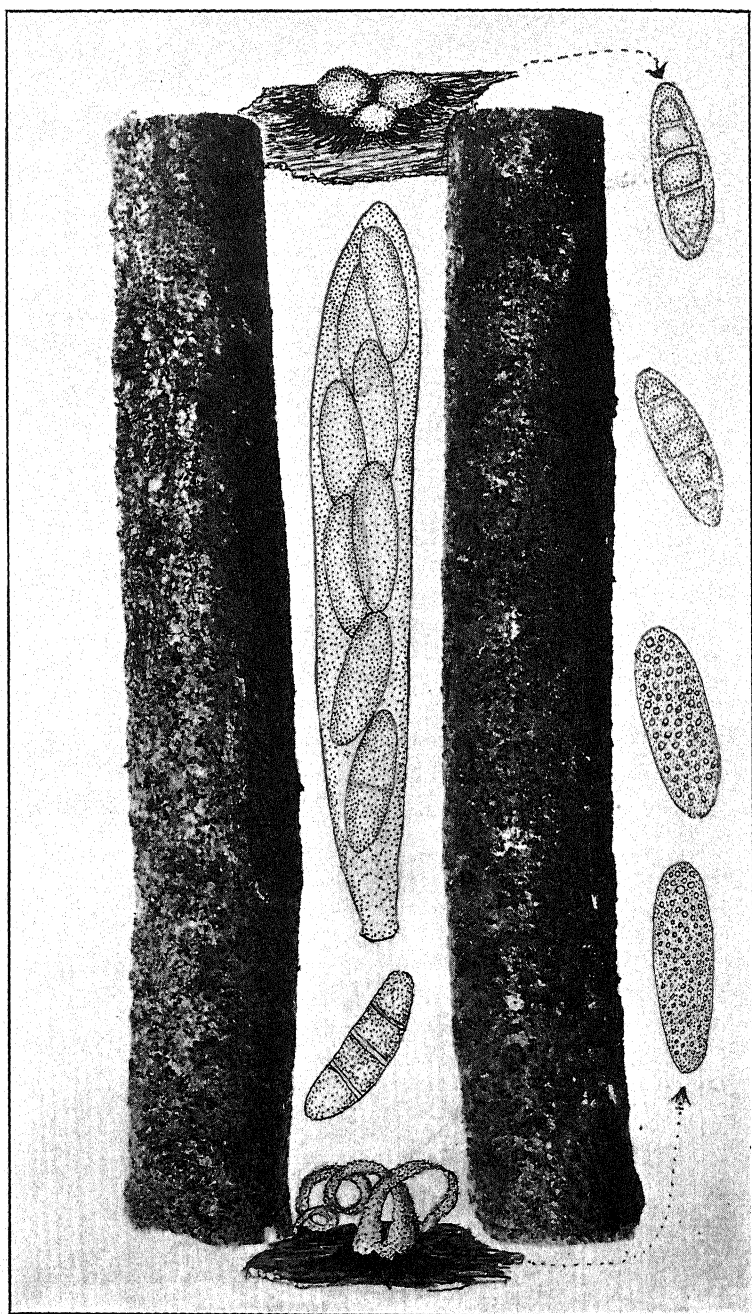


FIG. 2. *Pesicula cornicola*.

crowded in the ascus, $10-13 \times 28-34 \mu$; paraphyses filiform, slightly enlarged above.

On *Cornus alternifolia*, *C. stolonifera*, and unnamed species of *Cornus*.

TYPE LOCALITY: Idaho.

DISTRIBUTION: California to Oregon and Ontario.

EXSICCATI: N. Am. Fungi 2809 (as *Pezicula rhabarbina*).

This is accompanied by a *Myxosporium* which appears to be its conidial stage. The pycnosporos are ellipsoid and densely filled with granules, $13-15 \times 33-36 \mu$.

The identity of the Phillips and Harkness species is uncertain.

***Pezicula cornicola* sp. nov.**

Apothecia usually in cespitose clusters, individual apothecia sessile reaching 1 mm. in diameter, pale yellow; hymenium plane or slightly convex; asci clavate, reaching a length of $100-120 \mu$ and a diameter of $12-15 \mu$; spores partially 2-seriate, ellipsoid, straight or slightly curved, about $7-8 \times 20 \mu$, becoming tardily 1-3-septate; paraphyses filiform, slightly enlarged at their apices.

Apotheciis cespitosis, sessilibus 1 mm. diam. dilute-flavibus; disco plano-convexo; ascis clavatis, $100-120 \mu \times 12-15 \mu$; sporiis biseriatis, ellipsoidis, $7-8 \times 20 \mu$, 2-4 cellularibus; paraphysibus filiformibus, sursum clavulatis.

On bark of *Cornus* sp., East Hampton, New York, July, 1936.

This is associated with a *Myxosporium* which appears to be its conidial stage. The spores ooze out from the pycnidia in sausage like streams, whitish in color. The conidia are ellipsoid, or slightly narrowed at one end, quite variable in size but often reaching a length of 40μ and a diameter of 15μ , densely filled with minute granules.

EXPLANATION OF FIGURES

Fig. 1. *Pezicula Corni*. Center, photographs of several twigs showing apothecia; above, sketch of two apothecia, much enlarged; background, drawings of an ascus with spores; also two spores removed and the end of a ruptured ascus; below, drawing of a sorus and two conidia.

Fig. 2. *Pezicula cornicola*. Photograph of two branches showing apothecia. Above, sketch of apothecium, much enlarged; center, an ascus with spores; above right, two ascospores; below, a sorus with exuding conidiospores, much enlarged; below right, two conidia.

STUDIES IN THE GENUS MYCENA. IV¹

ALEXANDER H. SMITH

(WITH 3 FIGURES)

In the following account four species and one variety are described as new. One new combination is proposed and nine species are redescribed from studies of type material and fresh specimens. The writer is very grateful to Dr. Robert Kühner of Paris for his generous exchange of material, and his comments concerning many of the puzzling European species.

The collection numbers and photographs are those of the writer unless otherwise stated, and the specimens have been deposited in the Herbarium of the University of Michigan. The iodine solution used in determining the iodine reaction of the spores is made of five parts chloral hydrate, two parts water and an excess of iodine.

Mycena fuscoocula sp. nov. (FIG. 1, *a*, *b*, and *c*).

Gregaria; pileus 5–15 mm. latus, obtuse conicus demum campanulatus, glaber, fuscooculatus, demum pallide avellaneus; lamellae anguste adnatae, angustae, confertae vel subdistantes, sordide albidae; stipes 4–7 cm. longus, 1 mm. crassus, subviscidus, fuscus vel avellaneus, apice pallidus; sporae 10–12 × 5–6 μ , ellipsoidae; basidia tetraspora; cystidia valde elongata, 65–95 × 10–14 μ , levia. Specimen typicum in Herb. Mich. conservatum: legit prope Lake Quinault, Wash., Oct. 19, 1925, C. H. Kauffman.

Pileus 5–15 mm. broad, subconic at first, becoming more or less campanulate in age, moist, glabrous, at first "fuscous" on the disk and "avellaneous" or "cartridge buff" elsewhere, in age drab to "pinkish buff" with a paler margin, margin somewhat sulcate striate, not viscid; lamellae ascending, narrowly adnate, narrow, close to subdistant, whitish; stipe 4–7 cm. long, filiform or up to 1 mm. dia. tubular, subviscid to the touch, concolorous with the pileus or paler above, often "avellaneous" except for the whitish apex, strigose; spores 10–12 × 5–6 μ , ellipsoid, bluish gray in iodine; cystidia very abundant on the sides of the lamellae,

¹ Papers of the Herbarium of the University of Michigan.

65–95 \times 10–14 μ , very conspicuous, those on the edge shorter and with the apex forked at times.

Gregarious on needles, Lake Quiniault, Wash., Oct. 19 and 20, 1925, collected by C. H. Kauffman. The above description is taken from Kauffman's notes. I have not seen fresh specimens. The species is amply distinguished by its stature which relates it

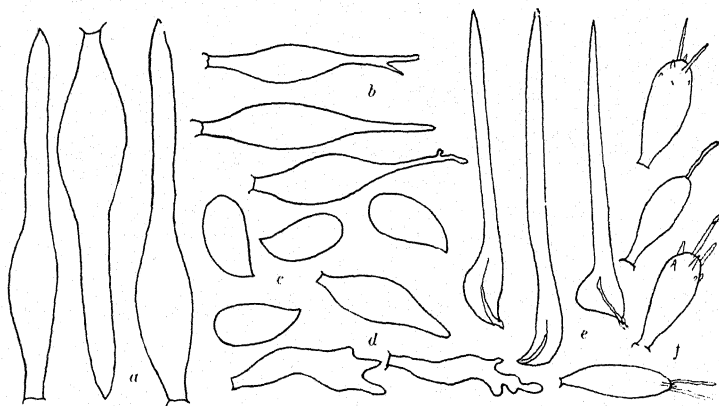


FIG. 1. a, b, c, *Mycena fuscoocula*; d, *M. texensis*; e, f, *M. codoniceps aciculata*.

to *Mycena filipes* (Fries) Quél., its long subcylindric pointed cystidia, and its large spores (four-spored basidia). Kauffman's notes describe the stem as subviscid and he had tentatively placed the species in the section Glutinipedes. In restudying the type, no gelatinous layer could be demonstrated. Consequently the species should be placed at least for the present in the old section Filipedes of Fries. *Mycena Font-Queri* Maire is apparently close to it, but is characterized by a shorter stem, thick walled cystidia and broad gills. The spores of the latter measure 10–11 \times 5–6 μ , but the basidia are described as two-spored.

***Mycena olivaceobrunnea* sp. nov. (FIG. 3, c).**

Gregaria; pileus 5–10 mm. latus, obtuse conicus, valde striatus, olivaceobrunneus demum sordide luteogriseus, glaber; lamellae subdistantes, adnatae, angustae vel sublatae, sordide luteogriseae, acie valde luteocitrinae; stipes 2–6 cm. longus, 1–1.5 mm. crassus, glaber, olivaceobrunneus demum pallide luteogriseus, tener; sporae 6.5–8 \times 4–4.5 μ vel 8–10 \times 4–5.5 μ , ellipsoideae; basidia tetraspora vel bispora; cheilocystidia fusioide ventricosa vel distorte ramosa.

Specimen typicum in Herb. Mich. conservatum: legit prope Lake Crescent, Wash., Sept. 20, 1935, A. H. Smith, n. 2507.

Pileus 5–10 mm. broad, obtusely conic, seldom expanding, moist, striate to the disk, "buffy brown" to "dark olive buff," paler on the margin, the striae dark and conspicuous, fading to sordid yellowish gray; flesh very thin and membranous, odor and taste not distinctive; lamellae subdistant, adnate, narrow or moderately broad at maturity, sordid yellowish gray, edge bright citron yellow; stipe 2–6 cm. \times 1–1.5 mm. polished, glabrous, "olive brown" below, "deep olive buff" or sordid yellowish gray above, rather weak and very fragile; spores $6.5\text{--}8 \times 4\text{--}4.5 \mu$ or $8\text{--}10 \times 4\text{--}5.5 \mu$ (two-spored), ellipsoid, pale bluish gray in iodine; basidia two- or four-spored; cystidia on the gill edge only, smooth, fusoid ventricose to saccate or with the apices more or less branched, occasionally with a few scattered blunt projections, $30\text{--}40 \times 8\text{--}18 \mu$; pileus trama with a thin pellicle below which is a broad region of inflated cells, the remainder is filamentose.

Densely gregarious on humus and needles under second growth of Douglas fir, Lake Crescent, Wash., Sept. 20 (no. 2507-type), and Oct. 22, 1935 (no. 3279). This species is verily closely related to *Mycena citrinomarginata* Gillet, but the smaller spores, darker colors, and more delicate stature readily distinguish it. *Mycena flavifolia* Peck. is also very close but the spores of the type measure $7\text{--}8 \times 5\text{--}6 \mu$, and the cystidia on the gill edge are covered by numerous blunt projections. In addition, the gill edge is apparently not differently colored.

***Mycena subsupina* sp. nov.**

Dense gregaria; pileus 3–7 mm. latus, conicus, centro fuscobrunneus vel olivaceobrunneus, demum avellaneus vel sordide albidus, sulcatus; lamellae distantes, angustae vel sublatae, adnatae; sordide albidae; stipes 1–2 (3) cm. longus, 1 mm. crassus, cartilagineus, fuscus vel cinereus; sporae (8) $9\text{--}11 \times 5.5\text{--}7$ (7.5) μ , ellipsoidae; basidia bispore et tetraspore; cheilocystidia $36\text{--}50 \times 8\text{--}14 \mu$, levia, fusoid ventricosa, rare ramosa. Specimen typicum in Herb. Mich. conservatum: legit prope Oric, Calif., Dec. 5, 1935, A. H. Smith, n. 3782.

Pileus 3–7 mm. broad, narrowly to broadly conic, with a delicate bloom at first, soon polished, near "mummy brown" when young, disk sometimes darker, at maturity "buffy brown" or with an ochraceous tint, margin pale avellaneous to whitish and somewhat sulcate in age, fading to pallid gray or watery grayish brown, hardly hygrophanous; flesh thin, rather tough, odor and taste mild;

lamellae distant, narrow to moderately broad, adnate or slightly toothed, white to pale grayish, edge whitish; stipe 1-2 (3) cm. \times 1 mm. equal, rather tough and cartilaginous, concolorous with the pileus or paler, with a rather large cavity, glabrous and polished except for the white strigose base, base not rooting; spores (8) $9-11 \times 5.5-7$ (7.5) μ , smooth, pale bluish gray in iodine, broadly ellipsoid; basidia two- or four-spored; cheilocystidia $36-50 \times 8-14$ μ , smooth, fusoid ventricose with subobtuse apices, with the apex forked or with two to several finger-like prolongations above an inflated basal portion; pileus trama with a thin adnate pellicle, beneath it a region of slightly inflated cells, the remainder homogeneous.

More or less decumbent and densely gregarious on redwood logs, Oric, Calif., Dec. 5, 1935 (no. 3782-type). This species has the consistency and stature of *Mycena supina*, but the cystidia separate it at once. The spores, in addition, are characteristically ellipsoid rather than globose. Those of *Mycena supina* are typically globose to subglobose but vary to broadly ellipsoid in two-spored forms. Spores of *M. subsupina* are typically ellipsoid, but may be subglobose in two-spored forms.

***Mycena texensis* sp. nov. (FIG. 1, d).**

Dense caespitosa; pileus 8-15 mm. latus, convexus demum late umbonatus vel subumbilicatus, viscidus, caeruleofuscus vel luteofuscus, demum cinereus vel luteocinereus; lamellae arcuate decurrentes, latae, subdistantes, pallide luteae, acie aurantiae; stipes 4-8 cm. longus, 1-1.5 mm. crassus, viscidus, apice pruinosis, luteogriseus vel aurantiogriseus; sporae $4.5-6 \times 3-3.5$ μ , ovoidae; basidia bispore; cheilocystidia $22-32 \times 5-9$ μ , fusoid ventricosa vel distorta ramosa. Specimen typicum in Herb. Mich. conservatum: legit prope Cisco, Texas, Sept. 8, 1935, E. A. Smith.

Pileus 8-15 mm. broad, oval to convex becoming broadly umbonate, the disk slightly depressed in age, glabrous, striate, margin subsulcate in age, viscid, nearly white when young, disk becoming bluish fuscous or dark grayish brown tinged with orange, the margin pale cinereous to whitish or tinged with orange yellow; flesh thin and pliant, odor and taste not known; lamellae moderately broad, arcuate decurrent, subdistant, whitish or pale yellowish to orange, margin deep orange (similar to *Mycena Leaiana* [Berk.] Sacc.); stipe 4-8 cm. \times 1-1.5 mm., equal, viscid, covered by a dense orange pruinose covering toward the apex, the base densely white or grayish strigose and rooting somewhat in the substratum, color yellowish to orange above, becoming whitish, sordid grayish

or sordid brownish toward the base; spores $4.5-6 \times 3-3.5 \mu$, bluish gray in iodine, ovoid; basidia two-spored (occasionally four-spored), $18-22 \times 4-5.5 \mu$; cheilocystidia $22-32 \times 5-9 \mu$, fusoid ventricose at first, soon with the apex more or less lobed or divided, sometimes with obtuse knob-like protuberances or variously contorted and irregular in outline; pileus trama with a thick gelatinous surface pellicle, more or less floccose below to the gelatinous subhymenium; gill trama with a gelatinous subhymenium when revived in KOH; stipe with a thick gelatinous layer over the surface.

Densely cespitose on oak logs and stumps west of Cisco, Texas, Sept. 8, 1935, collected by E. A. Smith. This species is closely related to *Mycena Leaiana*. The gelatinous surface pellicle of the pileus and stipe, the orange pruinose stem and yellowish to orange gills with the brighter edges and the densely cespitose habit all clearly relate it to that species. It differs in the very small spores, short narrow basidia and the grayish colors of the cap as well as in the shape and distribution of the cystidia. The above description is based on notes sent to me by Mr. Smith. I have not seen fresh material. However, the microscopic characters are at once striking and distinctive, and its relationship to *M. Leaiana* is obvious. When treated with chloral hydrate-iodine all the pileus trama except the gelatinous surface layer turns dark reddish brown.

Mycena rugulosiceps (Kauff.) comb. nov. (= *Collybia rugulosiceps* Kauff. Papers Mich. Acad. Sci. Arts and Letters 5: 126. 1926). This species was collected on several occasions in Washington, Oregon and California during the season of 1925. It was found on logs and sticks of *Vaccinium* and *Alnus* as well as on the wood of various coniferous trees. It also occurs on debris and sometimes apparently on humus. As in many of the larger species of *Mycena*, the margin of the pileus may be incurved at first or at least conivent with the stipe. As in *Mycena megaspora* Kauff. the gills occasionally stain reddish in age, particularly if the weather continues warm and wet. The colors of the pilei are variable, buttons are "blackish mouse gray" and as the cap expands the colors change to "drab" and finally become "avellaneous." The disk often remains a darker sordid brown. The cystidia measure $24-36 \times 8-12 \mu$, are clavate and the inflated portion is covered by rod-like projections. They are present only on the

gill edges. The spores measure $8-10 \times 6-7 \mu$, are broadly ellipsoid, and turn bluish gray in iodine. The pileus trama is characterized by a thin pellicle, beneath it is a compact region of enlarged pseudoparenchymatous cells (in tangential section), and the remainder is floccose and filamentose. The basidia are four-spored. This species is closely related to *Mycena Berkleyi* Masee, *Mycena megaspora*, *Mycena Grantii* Murrill, *Mycena magna* Murrill and *Mycena longipes* Murrill. From *M. Berkleyi* it should be readily separated by its larger spores. *Mycena Grantii*, which has no differentiated cystidia on the sides or edges of the gills and spores $5-6 \times 4-5 \mu$ (four-spored), is very close to *M. Berkleyi*. *Mycena magna* is characterized by spores $7-8.5 \times 6-7.5 \mu$ on two-spored basidia and by clavate-echinulate cystidia on the sides and edges of the gills ($28-34 \times 8-12 \mu$). It should be readily distinguished from those mentioned above in either the two- or four-spored form. *M. longipes* is characterized by spores $8-10.5 \times 6-7 \mu$, and a very pale slender stem. Its cystidia are clavate to saccate ($27-34 \times 8-12 \mu$) and in the type specimen both smooth and echinulate individuals were found. The basidia are two-spored. *M. longipes* should differ from *M. rugulosiceps* in having smaller spores in the four-spored form as well as in its very pale slender stipe.

MYCENA CODONICEPS (Cooke) Sacc. sensu Kuhner (4).

Pileus 1-3 mm. broad, obtusely conic, margin flaring in age, pale gray or brownish gray becoming sordid pallid gray in age, sulcate, at first densely setose, sparsely setose or glabrous in age, margin entire; flesh very delicate and fragile; lamellae narrow, narrowly attached or nearly free, subdistant, edge concolorous with the sides; stipe 1-3 cm. long, filiform, very soft and delicate, with a small rounded bulb at the base, gray, whitish in age, covered by setae, bulb also setose; spores $6-8 \times 3-4 \mu$, ellipsoid, pale yellowish or nearly hyaline in iodine; basidia two- and four-spored; cystidia on the gill edge only, $25-30 \times 7-9 \mu$, smooth, fusoid ventricose with blunt apices; pileus trama (revived in KOH) characterized by a narrow gelatinous pellicle above a vesiculose tramal body, numerous setae $150-200 \times 8-14 \mu$ arising in the pellicle and projecting, setae thick-walled, staining yellowish in iodine; stipe and bulb covered by similar or more elongated flexuous setae.

Scattered on spruce needles and leaves of Labrador tea, Rock River, Mich., June 17, 1933 (no. 33-537), and under clumps of ferns, Warrensburg, N. Y., Sept. 5, 1934 (no. 702). This is a characteristically gray species with large prominent setae, a gelatinous pellicle (at least when revived in KOH) and smooth fusoid-ventricose cystidia.

***Mycena codoniceps* var. *aciculata* var. nov. (FIG. 1, *e* and *f*).**

Gregaria; pileus 1-3 mm. latus, conicus, sulcatus, caeruleogriseus demum sordide albidus vel pallide cinereus, dense setosus, tener; lamellae confertae, latae, anguste adnatae, sordide albiae vel griseae; stipes 1-3 cm. latus, 0.3-0.4 mm. crassus, griseus demum albidus, dense setosus; sporae 7-8 \times 2.5-3.5 μ , vel 8-10 \times 4 μ ; basidia tetraspora vel bispora; cheilocystidia clavata, sparsim aculeata. Specimen typicum in Herb. Mich. conservatum: legit prope Oric, Calif., Dec. 2, 1935, A. H. Smith, n. 3704.

The variety differs from the species in the bluish gray colors of the pileus which soon fade to sordid whitish, the broader closer gills which at times separate from the base of the stipe but, by adhering to each other, form an inconspicuous collar around it, and by the cystidia on the gill edge which have sharp aciculate more or less elongated projections scattered over their apices. The spores of both are yellowish in iodine. In water mounts of fresh material of both the species and the variety, the pellicle does not appear to gelatinize, but when material is revived in two per cent KOH the pellicle often swells up to 15-60 μ thick and appears very gelatinous. The variety has been found on redwood cones, bark and twigs, Oric, Calif., Dec. 2 (no. 3704-type) and Dec. 5, 1935 (no. 3783); on alder leaves, Yellow Dog River, Marquette, Mich., Sept. 9, 1933 (no. 33-912), and on debris under pine, Warrensburg, N. Y., Sept. 6, 1934 (no. 714). The fruit-bodies are not uncommon but are very easily overlooked and very difficult to collect because of the size and delicate consistency.

MYCENA BREVIPES Murrill (FIG. 3, *b*₁).

Pileus (5) 10-25 mm. broad, ovoid, becoming obtusely conic, conic campanulate or convex, at first hoary, soon polished, glabrous, surface moist, striate almost to the disk, "deep neutral gray" and fading to "pale neutral gray" on the disk, sometimes "pale drab gray" over all, the margin usually "pallid neutral gray" and

radially rugulose; flesh thin, fragile, pallid gray, not changing, odor and taste not distinctive; lamellae adnate, narrow to moderately broad, subdistant to distant at maturity, intervenose at times, whitish to pale cinereous, edge concolorous with the sides and even; stipe 1.5–3.5 cm. \times 1.5–3 mm., equal or the base subbulbous, concolorous with the pileus, pale cinereous or nearly white, at first covered by a powdery bloom, soon polished, the base surrounded by a mass of white strigose filaments or echinulate with white hairs radiating from the point of attachment, not rooting, occasionally the base stained sordid purplish brown in age; spores (7) 8–10 \times 5–6 μ , ellipsoid, bluish gray in iodine; cheilocystidia (30) 40–60 \times 10–18 μ , fusoid ventricose with obtuse apices or abruptly ventricose with a long aciculate protruding neck, smooth; basidia four-spored; pileus trama with a thin pellicle, beneath it a region of large inflated cells, the remainder filamentose.

Singly on the dead branches and twigs of coniferous trees or on the branches and twigs covering the forest floor as well as on decaying sticks of alder. Lake Crescent, Sept. 20 (no. 2512), Crescent Beach, Sept. 22 (no. 2550), Quillayute River, near La Push, Oct. 26 (no. 3351), and by C. H. Kauffman at Lake Quiniault, Wash., Nov. 4, 1925. In Oregon it was found at Lake Tahkenitch, Nov. 17 (no. 3514), Nov. 18 (no. 3532) and Nov. 25 (no. 3612); in California, at Trinidad, Nov. 29 (no. 3643), Oric, Dec. 3 (no. 3742) and Dec. 4, 1935 (no. 3755). The cystidia of the type are similar to those described above, but reliable spores could not be obtained. Murrill described the species as growing on hardwood sticks. Kauffman's collection was on *Alnus*, but all of mine were on conifers. The outstanding positive characters of *M. brevipes* are the short stem, top heavy appearance, habit of growing singly, pale gray color, fragile consistency, fusoid cystidia on the gill edge and lack of an odor or taste. It is very difficult to determine whether or not this fungus is merely a form of a previously described species from Europe. It is close to *Mycena leptcephala* (Fries) Gillet.

MYCENA ELEGANTULA Peck.

Pileus 1–2.5 cm. broad, remaining obtusely conic, glabrous, moist, at first "warm blackish brown" to "dark vinaceous brown" on the disk and "livid brown" to "brownish vinaceous" on the margin, at times "hellebor red" or with a fuscous tinge on the

disk and "pale rhodonite pink" near the margin, hygrophanous, fading but retaining a decided pinkish gray or vinaceous cast, sulcate striate in age; lamellae bluntly adnate, narrow, distant to subdistant, white, the margins pale or bright pinkish brown; stipe 3–8 cm. \times (1) 2–3 mm., equal, cartilaginous and brittle, glabrous except for the white strigose base, translucent above at times, grayish with a vinaceous tint at very first, becoming nearly "pale hydrangea pink" or brighter toward the apex in age, sometimes fading and becoming nearly white; spores 8–10 \times 5–6 μ , broadly ellipsoid, bluish gray in iodine; basidia four-spored; cystidia scattered on the gill edges, absent or rare on the sides, 30–40 \times 8–15 (20) μ , fusoid ventricose with obtuse apices, smooth, sometimes forking or branching at the apex, filled with a pinkish sap; pileus trama with a thin pellicle, below it a region of inflated cells, the remainder homogeneous.

Cespitose to scattered on conifer logs and debris, Lake Crescent, Wash., Sept. 22 (no. 2545), Oct. 19 (no. 3262), and Oct. 22 (no. 3295); Lake Tahkenitch, Ore., Nov. 18 (no. 3528) and Nov. 22 (no. 3583), and Florence, Ore., Nov. 22, 1935 (no. 3606). This species differs from *Mycena purpureofusca*, which is also common along our Pacific Coast, in its predominantly pinkish to vinaceous cast contrasted to the dominant lilac-fuscous colors of the latter. In addition the gill edge of *M. purpureofusca* is much darker. In consistency *M. elegantula* resembles *Mycena inclinata* (Fries) Quél. The smaller spores distinguish it readily from *Mycena rubromarginata* (Fries) Quél. The fungus described by Smith (7) as *Mycena rubromarginata* var. *Laricis* is the two-spored form of *Mycena elegantula*.

MYCENA LAEVIGATA (Fries ex Lasch.) Quél.

Pileus 1–2 cm. broad, conic to convex or with a low subconic umbo, remaining broadly conic or convex, often with a small papilla, glabrous, lubricous or subviscid in age or when wet, at first pale fuscous watery gray or bluish gray on the disk and whitish toward the margin, soon fading and whitish over all, or at maturity with a cream colored disk, closely striatulate to near the disk, opaque at first; flesh thin, flaccid and cartilaginous, white, odor and taste not distinctive; lamellae moderately close and broad, broadly adnate-subdecurrent, white, edge even; stipe 2–5 cm. \times 1–2 mm. equal, cartilaginous and tough, base white strigose and rooting somewhat in the rotten wood, glabrous, cartilaginous and

brittle, tubular, when young bluish gray above, pallid below, soon fading to watery grayish white or shining white; spores $6-8 \times 3-4 \mu$, broadly ellipsoid, bluish gray in iodine; basidia four-spored; cystidia basidia-like or elongated and with wavy outlines, $28-45 \times 6-11 \mu$, smooth, on the gill edge only; pileus trama with an upper region of compact pseudoparenchymatous cells (tangential section), the walls of the uppermost cells gelatinizing somewhat causing the slippery or subviscid surface, tramal body floccose filamentose.

Cespitose to subcespitose on conifer logs, North Fork of the Mad River, California, Dec. 9, 1935 (no. 3919), and on conifer logs, Bear Island, Lake Temagami, Ont., Sept. 9, 1936 (no. 4733). The spores in both of the American collections are slightly below the range in size usually given for the species in Europe. The lubricous pale pileus, cespitose habit, broadly adnate gills and smooth cystidia amply characterize it, however. The margin may be either connivent or slightly incurved. This in addition to the structure of the pileus relates it to lignicolous species of *Collybia*. *Mycena radicatella* Peck is a very closely related species usually found on the wood of deciduous trees.

MYCENA NIVEIPES Murrill (FIG. 3, a).

Pileus (1.5) 2-7 cm. broad, ellipsoid when young, convex to obtusely conic or becoming nearly plane, the margin slightly recurved, "clove brown" to "olive brown" or sordid drab when moist, striate, hygrophanous, fading to whitish or various shades of sordid grayish brown on the disk, margin white and sometimes sulcate in age, often splitting; flesh thin and very fragile, taste acidulous to subfarinaceous, odor nitrous or lacking entirely; lamellae broad, close to subdistant, narrowly adnate or slightly toothed, at first faintly bluish gray, soon fading to white, at times white from the first, in age occasionally flushed with pink, edge even or slightly fimbriate; stipe 4-10 cm. \times 2.5-7 mm., very fragile, equal, hollow, pale bluish cinereous when young, becoming sordid or shining white, at first densely covered by a white fibrillose coating, longitudinally fibrous-striate in age or becoming glabrous, apex minutely scabrous at first, base more or less white strigose and sometimes subradicating; spores (7) $8-10 \times 5-6 \mu$, subglobose to ellipsoid, faintly bluish gray in iodine; cystidia abundant on the sides and edges of the lamellae, $50-90 \times 8-15 \mu$, smooth, narrowly fusoid, with subacute to acute apices, those on the edge often

fusoid ventricose and shorter ($40-60\ \mu$ long); pileus with a well developed pellicle, beneath it a region of slightly inflated hyphal cells which grades imperceptibly into the typical floccose filamentose tissue below.

Singly to gregarious or subcespitose on old logs of oak, elm, ash, maple, etc., usually in the spring or early summer. The above description was drawn from collection no. 3967, Dexter, Mich., June 4, 1936. This is a common species in northeastern United States and eastern Canada. It is described as *Mycena polygramma* var. *albida* by Kauffman (3), who placed it in the latter species because of its frequently striate stipe. After collecting this species frequently during the past eight years, it is clear to me that Murrill (6) described one extreme variation as *Mycena neveipes* and Kauffman another. The spores of Murrill's type measure $8-10 \times 5-7\ \mu$, and are broadly ellipsoid, the cystidia are abundant on the sides of the gills and measure $60-90 \times 8-12\ \mu$. They are fusoid, smooth, and have subacute apices. The cystidia on the gill edge are $38-50 \times 10-14\ \mu$, ventricose and smooth. The basidia are four-spored. Kauffman studied the species in its robust form as it develops in the spring. Murrill collected the late season form which is not as luxuriant and in which the fibrils on the stem are not conspicuous or soon disappear entirely leaving a shining white glabrous stipe. The odor is more apt to be absent in the late season form, but I have found collections of robust, odorless individuals in June. No. 971 from Warrensburg, N. Y., Sept. 2, 1934, and nos. 32-365, Stockbridge, Mich., Sept. 5, 1932, are the latest seasonal records I have of it. It is represented by no. 15195 in the Atkinson Herbarium at Cornell University, Ithaca, N. Y. (collected by H. S. Jackson), July 10, 1903. Atkinson had tentatively considered it as a new species. The large prominent cystidia, pale color, fragile consistency, and usually the odor separate it from *M. polygramma* (Fries) Quél. *Mycena subalpina* v. Höh. is apparently closely related to *M. niveipes*, but from the descriptions it is difficult to decide whether *M. Jacobi* Maire (*M. pseudogalericulata* Lange) is distinct from von Höhnelt's species. The spores of *M. Jacobi* are apparently larger than those of *M. niveipes*.

MYCENA PECTINATA Murrill.

Pileus (5) 10–20 (30) mm. broad, obtusely conic with a flaring margin or subexpanded in age, when young covered by a distinct glaucous hoary coating, soon polished, glabrous, “benzo brown” to “fuscous” on the disk, fading through drab to pale gray with a whitish margin, the margin at first darker grayish brown and usually tinged vinaceous on buttons, striate to near the apex, sulcate in age; flesh very thin and papery in mature caps; odor and taste not distinctive; lamellae adnate, close to subdistant, narrow to moderately broad, white, sometimes yellowish in age, intervenose, edge whitish and even; stipe 1–4 cm. \times 1–2 mm. “hair brown” and covered by a hoary coating, paler above, glabrous, base slightly enlarged at times and strigose with white hairs, very fragile; spores (7) $8\text{--}10 \times 4\text{--}5.5 \mu$, broadly ellipsoid, pale bluish gray in iodine; basidia four-spored; cystidia rare or scattered on the sides of the gills, more numerous on the edge, $40\text{--}50 \times 10\text{--}20 \mu$, with one or several finger-like prolongations or the apex mucronate, occasionally broadly fusoid ventricose; pileus trama with a thin pellicle, below it a broad region of inflated cells, the remainder filamentose.

Scattered to gregarious on sticks of *Vaccinium* and *Acer* and on needle beds under spruce in bogs. Common in the spring and early summer. The fragile consistency, thin sulcate brownish pileus with the whitish margin and broad, often mucronate cystidia distinguish it as a species. Murrill describes it as cespitose and up to 3 cm. broad, nos. 32–558 and 32–559 from a bog near Ann Arbor, Oct. 11, 1932, had pilei measuring 1–3 cm. broad. The microscopic characters of the type are the same as those given above, and the dried specimens are practically identical. It is closely related to *Mycena metata* but the cystidia distinguish it at once. *Mycena tenuicula* Murrill has similar cystidia but is easily distinguished by its consistency, more distant gills and tendency to stain reddish when bruised or in age. *Mycena intertexta* also has similar cystidia. I have not seen fresh material of either *M. intertexta* or *Mycena avellanea* Murrill, but a study of dried specimens indicates that they are very close to each other if not identical. The spores of the type of the latter measure $8\text{--}9.5 \times 6\text{--}7 \mu$. Both of these should be readily distinguished from *M. pectinata* by their densely cespitose manner of growth on decaying wood of conifers.

MYCENA POLYGRAMMA (Fries ex Bull.) Quél. (FIG. 2, a).

Pileus (1.5) 2-4 cm. broad, obtusely conic to oval at first, campanulate to plane or with an obtuse umbo in age, surface white canescent at first, the bloom often persisting until near maturity, glabrous and lubricous in age, color "fuscous black" beneath the bloom or "fuscous," fading slowly to "drab" or paler grayish, nearly "pinkish buff" at times, margin opaque and frequently sulcate, the surface often more or less uneven and appearing streaked with glistening lines, not hygrophanous; flesh very hard and cartilaginous, watery grayish to white, rather thin, odor none, taste mild; lamellae close, becoming subdistant as the pileus expands, broad (anteriorly), narrowed toward the stipe, narrowly adnate or with a short decurrent tooth, white or whitish, in age flushed with pink, often staining sordid brownish in spots, edge even; stipe 6-15 cm. long, 2-5 mm. dia. very brittle and cartilaginous equal, tubular, with or without a well developed pseudorhiza, base white strigose and often staining reddish brown, densely silvery longitudinally striate, twisted striate in some, "fuscous" or paler grayish brown beneath the silvery covering, at times nearly glabrous and smooth or glabrous and longitudinally grooved, apex pallid and faintly powdered, attached to sticks which are either on the surface or buried in the ground; pileus trama with a thick nongelatinous pellicle, beneath this a region of inflated irregularly arranged hyphae, the remainder of the floccose filamentose type; cystidia on the gill edge only, $26-34 \times (5) 7-10 \mu$, aciculate or the midportion somewhat enlarged and the apex forked or branched giving rise to two or several contorted finger-like projections, spores $7.5-10 \times 5-6 \mu$, broadly ellipsoid, pale bluish in iodine; basidia four-spored.

Gregarious to subcespitose under maple and basswood, South Lyons, Mich., Oct. 6, 1936 (no. 5036). There has been much confusion in North America in regard to this species. The material cited above is similar in every respect to material from France by Dr. R. Kühner, and from England by Mr. A. A. Pearson. No. 16464 in the Atkinson Herbarium at Cornell University was collected by Atkinson near Paris and the determination checked by N. Patouillard. It and material sent to Atkinson by Romell are the same as the material cited above. Atkinson had also collected the species in New York (no. 18684). Tall slender forms of this species resemble *Mycena pullata* (Berk. & Cooke) Sacc. or *Mycena praelonga* Peck in appearance. The former is

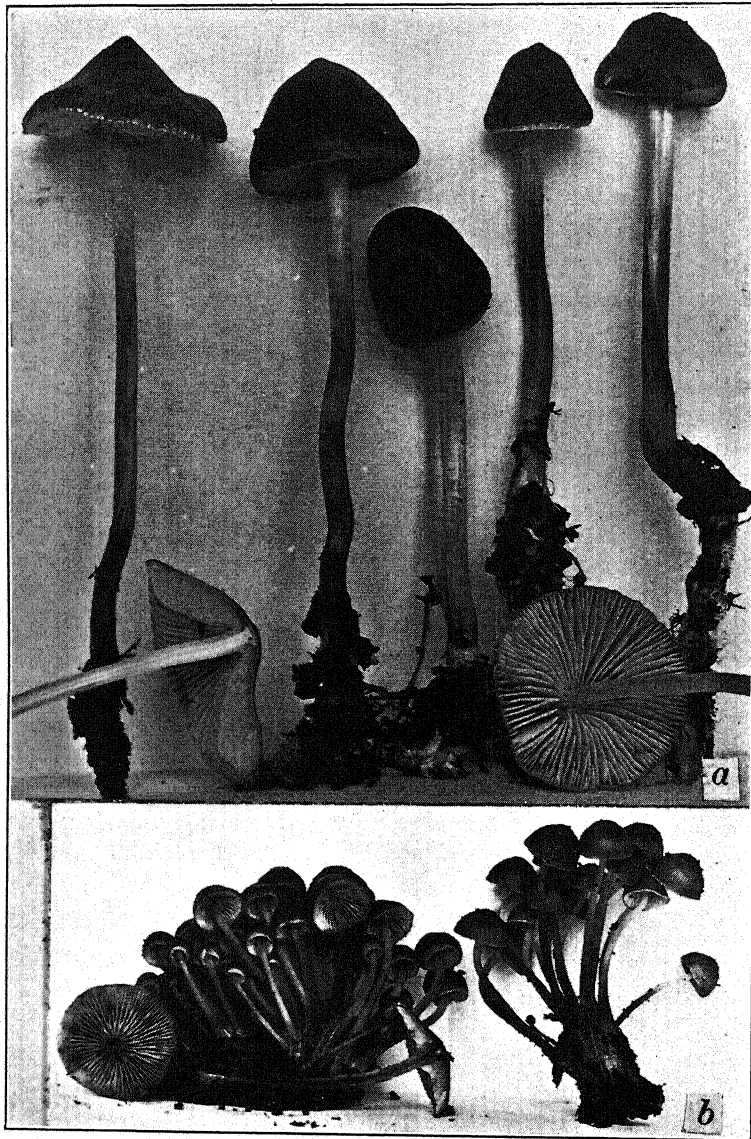


FIG. 2. a, *M. polygramma*; b, *M. tintinnabulum*.

readily distinguished by its color and the latter by its relationship to *M. alcalina* and habitat on sphagnum.

MYCENA TINTINNABULUM (Fries) Quél. (FIG. 2, *b*). (= *Omphalia semivestipes* Peck, Bull. Torrey Club 22: 200. 1895. *Omphalia curvipes* Peck, Bull. Torrey Club 34: 345. 1907. *Mycena subalcalina* Atk. Am. Jour. Bot. 5: 37. 1918.)

Pileus 1–3.5 cm. broad, convex to plane or slightly umbonate, blackish or with a bluish black sheen when young, slowly fading and becoming grayish or sordid whitish in age, at times the margin becoming ochraceous tinged, in wet weather often staining sordid reddish brown, lubricous to subviscid, opaque when moist, becoming closely translucent striatulate on the margin when fading, margin straight or slightly incurved at first; lamellae narrow to moderately broad (2–3 mm.), close (subdistant in broadly expanded pilei), broadly adnate or slightly decurrent, pallid to white, at times pallid fuscous in age, often tinged sordid flesh color or with reddish brown spots, edge even and whitish to grayish; stipe 2–6 cm. \times 1–3 mm. tubular, terete or compressed above, slightly pruinose, soon polished, concolorous with the pileus or paler, becoming reddish or blackish brown at the base in age, base white strigose, very tough and cartilaginous; spores 4–5 \times 2–3 μ (5–6 \times 3 μ or 3–4 \times 2 μ), pale bluish gray in iodine, smooth, broadly ellipsoid; cystidia rare or scattered on the sides, 25–30 \times 9–11 μ , saccate, occasionally with knob-like processes at the apex or smooth and with wavy outlines, those on the gill edge similar or scarcely differentiated from sterile basidia; basidia four-spored; pileus trama with a thin gelatinizing pellicle, beneath it a region of slightly enlarged cells, the remainder floccose filamentose, becoming reddish violet in iodine; odor strongly alkaline at first but soon vanishing, frequently entirely absent.

Densely caespitose or densely gregarious on old stumps and logs, particularly of basswood. This is a common species during wet cool weather in late October or November throughout the Great Lakes Region and eastern North America. Overholts (no. 1452; 1526; 2315) has collected it in Missouri and Ohio, and Hesler has recently found it in Tennessee during the month of January. The microscopic characters of the type of *M. subalcalina* and *O. curvipes* are the same as those given in the above description. Expanded fruit-bodies in my collections correspond very closely to the illustration of Fries (2), and his description (1) of the macro-

scopic characters covers my collections very well. Material so determined in the Atkinson Herbarium at Cornell University, which was sent to Prof. Atkinson by Romell, has the characteristically small spores and the thin gelatinous pellicle over the

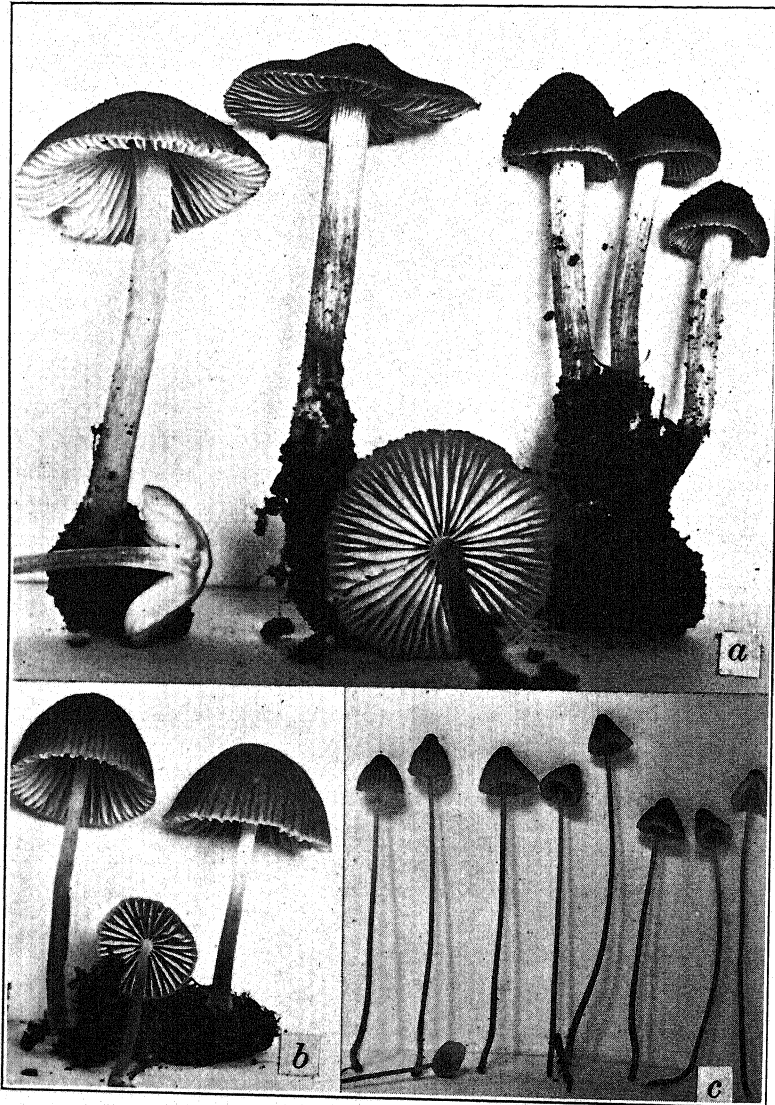


FIG. 3. a, *M. niveipes*; b, *M. brevipes*; c, *M. olivaceobrunnea*.

pileus. Meier (5) points out that the spores as given by Ricken are too large and states that in his own collections they measure 5.5–2.7 μ . The broadly adnate-subdecurrent gills led Peck, who had collected the small odorless form, to place it in *Omphalia*. Atkinson placed great emphasis on the odor as is indicated by the name he gave it. My experience with this species shows that the odor is a very unreliable character. It is often very strong while the fruiting bodies are attached to the substratum, and I have located clumps twenty to thirty feet away by "following my nose." However, within a few minutes after collecting these specimens the odor was no longer present and was not detected at any later time during the process of studying and drying them. On other occasions I have collected perfectly fresh material in which the odor was not present. The type of *Omphalia semivestipes* is very much like a large fruit-body of *M. tintinnabulum*. Its spores measure 5–6 \times 2–3 μ , and a thin gelatinous pellicle covers the pileus. No differentiated cystidia were found, but since they are nearly always rare and not greatly enlarged, this difference is not taxonomically important. The strigose covering over the lower portion of the stipe should not be considered important either since it is obviously the portion which was buried in the substratum. Most of the lignicolous species of *Mycena* in the old section *Rigidipedes* of Fries are characterized by a subradicating strigose stem base. The most reliable characters of *M. tintinnabulum* are the small spores, broadly adnate-subdecurrent gills, poorly differentiated cystidia, pliant cartilaginous consistency and lubricous to subviscid pileus.

LITERATURE CITED

1. Fries, Elias. *Hymenomycetes Europaei*. 1874.
2. ——. *Icones Selectae Hymenomycetum*, vol. 1. 1867.
3. Kauffman, C. H. *The Agaricaceae of Michigan*. 1918.
4. Kühner, Robert. Contribution a l'etude des Hymenomycetes et spécialement des Agaricaces. *Le Botaniste* 17: 1–224. 1926.
5. Meier, William. Einige nicht häufige Funde. *Zeitschr. Pilzkunde*. 13: 139–140. 1934.
6. Murrill, W. A. *Prunulus*. *N. Am. Flora* 9: 319–343. 1916.
7. Smith, Alexander H. Investigations of two-spored forms in the genus *Mycena*. *Mycologia* 26: 305–330. 1934.

MYCOLOGICAL NOTES. I

C. L. SHEAR

Under the above title the writer proposes to present a series of notes on various genera and species of fungi. These records have been accumulating for many years. They are based chiefly upon the examination of type or authentic specimens of the species of the older mycologists. The brief and imperfect descriptions of the early authors have led to many doubtful or erroneous determinations of their species. The writer has fortunately had an opportunity during the past 40 years to examine the herbaria of most of the older European and American mycologists for which he wishes to express again to those of the curators and directors of the various herbaria who are still living his appreciation and gratitude for the kindnesses and facilities provided.

1. DISCELLA EFFUSA B. & B. = GLOMERELLA CINGULATA (Stone) S. & V. S.

CONIDIAL FORM

A specimen in Michener's Herbarium, labelled "*Discella effusa* B. & C.," on a partly decayed apple collected by Michener in Pennsylvania, No. 647, is evidently part of the type collection. The last "B" in the authority as printed is probably a typographical error for "C." If it were intended for Broome, it would probably have been written "Br."; the usual form of abbreviation used by Berkeley. The number 3541 given by Berkeley in his "Notices of North American Fungi," No. 466, *Grevillea* 2: 100, 1874, probably refers to the number under which Michener's specimen was sent to him. It appears that Curtis did not use Michener's numbers in transmitting his collections to Berkeley for identification. The specimen shows a typical circular decayed area of an apple in which the spore masses have nearly all been eaten away by insects or washed away, leaving only the acervuli surrounded by whitened portions of the epidermis of the fruit

and thus giving them a slightly superficial suggestion of *Discella*. The spores are typical of the bitter rot of apple. Spore measurements given by Berkeley are ".0008 long \times .00016 wide."

2. *HERCOSPORA TILIAE* Fries and *RABENHORSTIA TILIAE* Fries

The genus, *Hercospora* is frequently attributed to Tulasne. It was, however, published by Fries in his Syst. Orb. Veg. p. 119, 1825. Following the description he says: "The types are *Sph. Tiliae* and *Sph. atrovirens*." The type as interpreted by Tulasne and later authors is *H. Tiliae* Fries. Fries did not actually write the combination *H. Tiliae* and it is usually attributed to Tulasne. In Sum. Veg. Scand. p. 397, 1849, Fries again describes the genus, but does not mention or include either of the species given in Syst. Orb. Veg. l. c. This fungus is very fully described and illustrated by Tulasne, Sel. Fun. Carp. 2: 154-158, Pl. 18, figs. 1-18, and Pl. 19, figs. 1-14. The fungus is not given in Ellis & Everhart, N. A. Pyren., but it is mentioned as a possible synonym of *Melanconis Tiliae* Ellis, p. 525, and there are very few American specimens in the Bureau of Plant Industry herbarium. All are on *Tilia*. They are as follows:

- No. 2522—Ellis & Everhart, N. Am. Fungi, collected in Canada by Dearness.
- No. 2952—Ellis & Everhart, N. Am. Fungi, collected at Wilmington, Del., by Commons.
- No. 1421—Shear, 1903; also without number, Washington, 1910, Bliss, Iowa, 1927.
- No. 1834—Nuttall, from W. Va.
- No. 3990—Shear on old cut branches of *Tilia* sp., Roaring Gap, N. C., 1934.

Most of the specimens of this in the herbarium both European and American are poorly developed, showing only small stromata and the perithecia few or none. The species is well marked, however, in this condition by a distinct circular black line surrounding the light colored tissue of the bark in which the perithecia appear. The perithecia are frequently associated with *Rabenhorstia Tiliae* Fries, which is regarded by Tulasne, Winter and others as its pycnidial form, but this has not been proven by pure cultures so

far as we know. Wehmeyer apparently did not study the fungus, as we find no mention of it in his papers. The Roaring Gap specimens cited are fully developed in both the pycnidial and perithecial stages. The pycnidial form agrees with that described and illustrated by Tulasne, l. c. The pycnidia are obtuse, conical, thick, black and surmounted by a depressed globose mass of nearly hyaline pycnospores, $12-15 \times 6 \mu$. Tulasne says $11-13 \times 6\frac{1}{2} \mu$. The locules are located on the sides of the inner wall of the pycnidium and the base is poorly developed, and does not form a distinct wall. On this account the pycnidia are very easily detached from the bark and soon disappear after fruiting, leaving only a slight dark colored depression surrounded by the epidermis. The perithecia form from a stroma in the same spot left by the base of the pycnidium, and in our Roaring Gap specimens the perithecia have formed and the ostioles grown up about the old neck of the pycnidium. The ascospore measurements as given by Tulasne are $16-22 \times 10 \mu$. I have examined various European specimens, as follows:

Herb. Bresadola, Gocciadora, Apr., 1923, spores $15-19 \times 7-9 \mu$.

Sacc. Myc. Ven. No. 676, spores $15-18 \times 7-8 \mu$.

Petrak No. 417, spores $13-18 \times 6-8 \mu$.

Krieger, Fun. Sax. No. 381, $15-18 \times 6-7 \mu$.

Winter gives ascospore measurements of this species as $24-26 \times 12-13 \mu$.

As will be noted the measurements of Tulasne and Winter exceed those of any European or American specimens we have seen. They would seem to be incorrect; or is there another species in Europe? The American specimens cited vary from $15-19 \times 7-9 \mu$. They are very variable in shape, and when fresh the spore contents show a rather peculiar vacuolose granular appearance. They become 1-septate at maturity, but we have seen none showing color. Sometimes there is a slight constriction at the septum. It seems probable that the fungus is rather widely distributed in this country wherever the host occurs, but that it is not often found in a well developed condition.

Traverso says: Fl. Ital. Cryptogama 2: 189, 1906, that the ascospores are $18-24 \times 8-10 \mu$ and cites Sacc. Myc. Ven. No. 676

as above, but we found none so large in our specimen of this number. He says *Hercospora* is distinguished from *Melanconis* by its different pycnidial form, and the pseudostroma which is limited by a black zone surrounding the perithecia.

3. NAUMOVIA Dobr., 1928, ROSENSCHELDIA Speg., 1883, GIBBERIDEA Fuckel, 1869, and MELOGRAMMA Fries, 1849

NAUMOVIA Dobr., Bolez. Rast. (Morbi Plant.) 16: 197. 1928.

The type species, *N. abundans* Dobr., described and illustrated, l. c., is represented by two specimens in the Bureau of Plant Industry Herbarium, one on dead stems of a Labiate, probably *Prunella vulgaris* collected by the writer above Chain Bridge, Va., May 31, 1920, and another on *Prunella vulgaris* collected at Hartford, Wash., July 1920, by C. R. Stillinger. The first specimen referred to is not quite mature, the spores only showing faint color in mass and obscurely septate; but agrees in every respect with Dobrozrakova's description and illustration, except that she says that there are no paraphyses present. Our specimens show clearly filiform paraphyses or rather what Petrak would call paraphysoids, being attached at both the base and apex of the perithecium or locule, forming apparently a sort of tissue-like network, though branches are not easily demonstrated. The structure is very similar to that found in the kernel of *Physalospora* and *Botryosphaeria*, the young perithecia being packed with a white tissue-like mass characteristic of the Pseudosphaeriaceae. The second specimen from Washington State is in a young condition and shows this character, the compact white center of the locules, very distinctly.

Comparing these specimens with *Rosenscheldia Heliopsidis* (Schw.) T. & S., the similarity in all the characters of the specimens both macroscopic and microscopic is very marked. About the only difference to be observed is in the size and shape of the spores which in the latter species are $28-30 \mu \times 4-5 \mu$, and in the former according to the author $30-39\frac{1}{2} \times 1\frac{1}{2}-3 \mu$. The author says 1-6 septate, though 4 are the most shown in his illustration and 3 is the usual number in our specimens.

A good mature specimen of Dobrozrakova's species on *Prunella vulgaris* from Lake Temigami, T. F. E., Ontario, No. 3509, was sent by Dr. Jackson, collected June 20, 1932; also another specimen on *Mentha* sp., from Morristown, Nova Scotia, collected by A. Rolland June 29, 1934. It is clear from a study of these specimens and the illustrations that *Naumovia* Dobr., 1928, is a synonym of *Rosenscheldia* Speg. 1883, differing only in its narrower ascospores which possibly become more septate.

ROSENSCHELDIA Speg. Anal. Soc. Sci. Argent. 19: 250. 1886

The type of the genus *Rosenscheldia* is *R. paraguayana* Speg. l. c. The original specimens of this were examined and fully described by Theissen & Sydow, Dothidiales, 648-49, and illustrated with a diagrammatic section of a stroma with locules, Pl. 4, fig. 11. The separate, closely gregarious or caespitose, sub-stipitate locules are without true ostioles, but rupture at the apex when mature by dissolution (lysigeny) of the tissue. The asci are in a mass arising from the base; paraphyses (paraphysoids of Petrak) present; spores becoming 4-celled, fusiform, pointed, $27-31 \times 3 \mu$, grayish brown, indistinctly septate.

MELOGRAMMA Fries 1849

Von Höhnelt in discussing the above species, Frag. Myc. 13: No. 708, after studying Roumeguere's Fungi Sel. Exs. No. 4155, which Theissen & Sydow cite as Spegazzini's species, says that it is very similar to *Melogramma vagans* and that Spegazzini's type should be referred to *Melogramma*. We have studied a specimen of *Gibberidea obducens* Rick which Theissen & Sydow say is the same as Spegazzini's type *R. paraguayana*, and also *Montagenella Heliopsodis* (Schw.) Sacc., and of which we have abundant material, which Theissen & Sydow regard as a typical *Rosenscheldia*. These are evidently closely related species having the same internal structure of the locules and congeneric.

Theissen & Sydow, l. c., 649, say that as the type of *Rosenscheldia* is a genuine Dothideaceous fungus, to compare it with typical Sphaeriaceous perithecia (as in *Melogramma*) is out of the question. This remark refers to von Höhnelt's opinion just noted in regard to its relation to *Melogramma*. A careful study,

however, of *M. vagans*, the type of *Melogramma* in different stages of development shows that there are no separate paraphyses, but an indistinct network of more or less filiform, gelatinous hyphae surrounding the kernel of the locule, which becomes modified toward the apex and appears as paraphyses just below the ostiole. The inner wall of the locule is distinctly darker colored than the surrounding stroma, but not readily separable from it. The ostiole is somewhat like that in the Sphaeriaceae but rather intermediate between that and *Rosenscheldia*. These genera are closely related, but seem generically distinct. *Melogramma* is evidently a connecting link between the Pseudosphaeriaceae and the Sphaeriaceae. There is a difference of opinion among students of these fungi in regard to the presence or absence and character of the paraphyses. Von Höhnelt says that *Melogramma* has abundant paraphyses. Tulasne also describes and figures paraphyses showing a few irregular filiform hyphae. Winter and others say paraphyses are present; but, as has been noted above, we find no true paraphyses intermingled with the asci. Such more or less filiform and united hyphae as surround the kernel of asci do not readily separate and can scarcely be considered true paraphyses. Theissen & Sydow and von Höhnelt describe *Rosenscheldia* as having abundant filiform paraphyses. As already stated the so-called paraphyses are only found as separate filaments of the network of hyphae in which the asci are developed and which tend to become separate at the maturity of the asci and finally disappear.

GIBBERIDEA Fuckel, Symb. Myc. 168. 1869

The monotype of this genus, *G. Visci* Fuckel, l. c., appears to be a rather rare fungus and confined to the host, *Viscum album*, so far as known at present. Petrak, Mycologische Notizen, Ann. Myc. 23: 58-61, 1925, reports a study of typical specimens of this species, his number 2099, Fl. Boh. & Mor. Exsic. He says this has the same structure of perithecia or locules and kernels as in the Cucurbitariaceae, and that it scarcely differs from *Rosenscheldia* as represented by *R. Heliopsidis* (Schw.) Theiss. & Syd. The structure of the kernel completely agrees, but the stroma is somewhat different and the genus (*Gibberidea*) may be kept

separate for the present on that basis. An examination, however, of Petrak's specimen No. 2099 shows that it agrees in structure with *Rosenscheldia obducens* Rick which is the same as *R. paraguayana* Speg., the type species, in practically every particular except that it has slightly less basal stroma and different sized spores. It also agrees in all essential characters with *Naumovia* Dobr., except for spore size. Dearness who examined a specimen of *G. obducens* from Rick which Weir sent him as No. 20,718 has a note with the specimen saying "I propose *Pseudomeliola Menthae* as n. sp. pro tem." The asci according to his measurements were $60-100 \times 6 \mu$, the spores $30-42 \times 2\frac{1}{2}-3\frac{1}{2} \mu$. The specimen is typical *G. obducens* of Rick. Dearness adds that he has not seen the description of Rick's species. We have examined the following specimens of it:

No. 75 from the herbarium of Bresadola on living stems of *Mentha* sp. collected by Rick in Brasil. No. 1561 Rehm Ascom. Exs. on living stems of *Mentha*, São Lopoldo, Brasil, Rick. Spores $30-39 \times 3$. No. 20,718 Herb. Weir on *Mentha* collected by Rick, same locality as above; also another on a Labiate plant from São Cruz, Brasil, 1927, Rick.

All these specimens are typical *Rosenscheldia* and equal *R. paraguayana*, the type of Spegazzini's genus.

It is interesting in this connection to note that Dobrozrakova, Morbi Plant. 16: 212, 1928, says in comparing his *Naumovia* with the type of *Gibberidea*, *G. Visci*, that it differs generically in belonging to the Scolecosporae. He also compares *G. obducens* (*Rosenscheldia paraguayana*) with his species and concludes that it should be transferred to *Naumovia*. He was apparently not familiar with the genus *Rosenscheldia*, of which *Gibberidea obducens* was really the type.

From the above discussion it is concluded that *Naumovia* Dobr. 1928, *Rosenscheldia*, Speg., 1883, and *Gibberidea* Fuckel, 1869, are synonyms and that the following species should be called *Gibberidea*: *G. Visci* Fuckel, *G. paraguayana* (Speg.) n. comb., *G. Helio-opsidis* (Schw.) n. comb., and *G. abundans* (Dobr.) n. comb.

4. PLEUROSOMA Tul. 1863 and NEOARCANGELIA Berl. 1905

Recently abundant material of *Sphaeria ootheca* Berk. & Curt. *Coronophora ootheca* (B. & C.) Sacc. was found on dead oak near

Rosslyn, Va. We find by an examination of Schweinitz' specimen and as indicated by Berkeley, that it is *S. mucida* var. *rostellata*, Schw. Syn. N. Am. Fungi, No. 1515, 1832. Von Höhnelt, in Myc. Frag., Ann. Myc. 16: 129 and 131, 1918, says that *Neoarcangelia* Berl. Icon. Fung. 3: 6, 1905, is identical with *Pleurostoma*, Tul. Sel. Fung. Carp. 2: 247, except that in the former the ostioles are more nearly vertical as shown in No. 2078, Rehm Asco. Exsic. A comparison of our specimens with the description and illustration of Berlese, l. c. pl. 7, which were drawn from the original American material described by Berkeley & Curtis, indicates that they agree in every particular, except that there is the greatest variability in the orientation of the perithecia which show all intermediate conditions between those with ostioles pointing laterally, to those exactly vertical. Apparently typical material of *Pleurostoma Candollei* Tul. l. c. distributed by Weese in Eumycetes Sel. Exsic. No. 20 on oak, agrees in all particulars with the descriptions and illustrations of Tulasne and of Berlese, except that we do not find any such distinct substipitate base to the perithecia. Most of them are entirely sessile, lying rather loosely, but slightly attached to the substratum so that they are easily removed by a light touch. Comparison of asci and spores of Berkeley's specimens and ours indicate that the two genera are not only identical, but *P. Candollei* and *N. ootheca* are one and the same species. The asci, which are supposed to be somewhat different in shape are most variable, ranging from subglobose to pear-shape or clavate. The size of the spores covers the same range in both cases. According to Tulasne, the ascospores are $3.5\ \mu$ long; according to Berlese they are $4-5 \times \frac{1}{3}\ \mu$ and in *N. ootheca* $2-3 \times 1$. We find in neither species ascospores exceeding $3.5\ \mu$ in length.

As to variability in the direction of the ostioles, this appears to be simply the result of the physical conditions under which the perithecia develop. According to descriptions and to the material we have examined, the perithecia arise on the surface of the wood beneath the bark of dead and dying oak branches. The bark is apparently so thick and hard that the ostioles are unable to penetrate it; therefore they turn more or less to one side on account of the pressure from above.

The fungus is evidently closely related to *Romellia* Berl., differing only in the shape of the ostiole and the polysporous asci. It differs from *Coronophora* to which it was referred by Saccardo in having the asci arranged on branching stipes and the perithecia in valsoid groups. The fungus may not be rare in this country, as it is easily overlooked on account of the location of the perithecia, which appear to remain covered by the bark for a long time and show no external indication of their presence.

5. SPHAEROPSIS UVARUM Berk. & Curt. Grevillea 3: 1, September
1874

This species is represented in the Curtis collection in the Farlow herbarium by a specimen numbered "4031, Curtis" on a Scuppernong grape, collected, according to the label, September 1853, at Society Hill, South Carolina. This is the only number and only specimen cited by Berkeley in the original description. A careful comparison of sections of this specimen with the descriptions and figures of Viala, and Istvanffi in his monograph on *Coniothyrium diplodiella* (Speg.) Sacc. as well as with specimens of this species distributed by Briosi and Cavara in their *Fun. Parasit. Plan. Colt.*, No. 48, collected at Como, Italy, September 1887, shows that the two organisms are the same. The external characters of the specimen in the Curtis collection and that of Briosi and Cavara as cited are identical. The appearance of this fungus under a hand lens, as indicated by these two specimens, is apparently characteristic and easily recognized. It seems to be distinguished from all the other fungi occurring upon the grape by the grayish, furfuraceous appearance of the pycnidia, which are very numerous and rather closely arranged, or sometimes confluent over the surface of the shriveled berry. This grayish furfuraceous appearance seems to be due to a sort of efflorescence of the epidermis of the grape, covering the pycnidia and thus obscuring the naturally dark color of their walls. All the macroscopic and microscopic characters of these two specimens agree so closely that there can scarcely be a doubt as to their identity. This is apparently a rare species in this country.

NOTES AND BRIEF ARTICLES

BOHUMIL SHIMEK, 1861-1937

Professor Bohumil Shimek, a charter member of the Mycological Society, was born in Johnson County, Iowa, June 25, 1861 and died at Iowa City, January 30, 1937. Except for two years spent as an instructor at the University of Nebraska, the bulk of his life was spent in Johnson County. Graduated from the State University of Iowa as a civil engineer in 1883, his connection with the University as a teacher began in 1890 and continued until his death. Successively, instructor, assistant professor (1893), professor (1903) and head of the department of botany (1914) he retired from the latter position in 1919 to devote himself more freely to his studies. In 1932 he was made research professor. In 1913-14 he was exchange lecturer at the University of Prague, from which institution he received an honorary Ph.D.

Professor Shimek's interests in natural science were unusually varied. Trained as an engineer, he did active field work in geology and for a time taught zoölogy. Several of his papers, especially those dealing with the problem of the loess and its fossil contents, reflect these interests. He was an indefatigable collector and used to say that in the course of his work he had walked across every one of the ninety-nine counties of Iowa. In addition he took extensive trips to other regions, including Nicaragua, New Mexico and the Gulf states. He published little or nothing on the fungi, but collected assiduously, and the mycological collections of the University of Iowa contain many of his specimens. From his very last trip, to the Mississippi sand dunes, in November, 1936, he brought in several uncommon species.

His chief interest was in the ecology of the prairie and he became known as one of the best informed American botanists on this subject. He was an ardent and militant conservationist, maintained a vigorous interest in civic affairs and was active and influential in Bohemian societies in the United States.

In 1886 he married Anna Konvalinka of Iowa City. After her death he married Margaret Meerdink, who was his constant companion on his later collecting trips and who survived him only a little over two months.

Professor Shimek was almost the last of the old-fashioned naturalists—men who were interested in every phase of natural history and who insisted upon familiarity with their material under natural conditions. Without deprecating the intensive specialization and necessary laboratory restriction of much of our modern study, it may be maintained that the combination of broad background and extensive field work exemplified by naturalists of this type has made an important contribution to the general biological picture and may again prove a necessary approach to many of our more general problems.—G. W. MARTIN.

MYCOLOGICAL SOCIETY OF AMERICA

THE SUMMER-FORAY, SEPTEMBER 3-5, 1936

(WITH 4 FIGURES)

Through the courtesy of Professor Ivey M. Lewis, director of the Mountain Lake Biological Station, the Society was able to hold its summer meeting at Mountain Lake, Virginia. This station, situated approximately 4000 feet above sea level furnished the members excellent laboratory facilities with plenty of working room, and at the same time comfortable sleeping quarters were available in the cabin type of dormitories, each of which was equipped with an open fireplace before which members gathered to talk and to bask in the cheer emanating from the wood fires.

As was true nearly everywhere else, the summer had been dry, but just prior to our arrival on September third, there had been a few small showers which furnished sufficient moisture to start the growth of fungi. In the beech woods mixed with maple and other broad-leaved trees of the region, and in the hemlock woods and Rhododendron thickets along the ravines below the camp, the covering of the forest floor was amply moist to support the growth of a wide variety of fungi. In the relatively open oak woods

around and above the camp, however, there was less moisture and fewer of the larger fungi. This state of affairs was soon remedied, for the day after the arrival of the main contingent, cool rains fell, followed by heavy mists, and it was not long before the agarics were pushing up on all sides. As a result, collecting was all that one could ask for, whether the main interest were in the smaller ascomycetes or in the larger basidiomycetes, as is witnessed

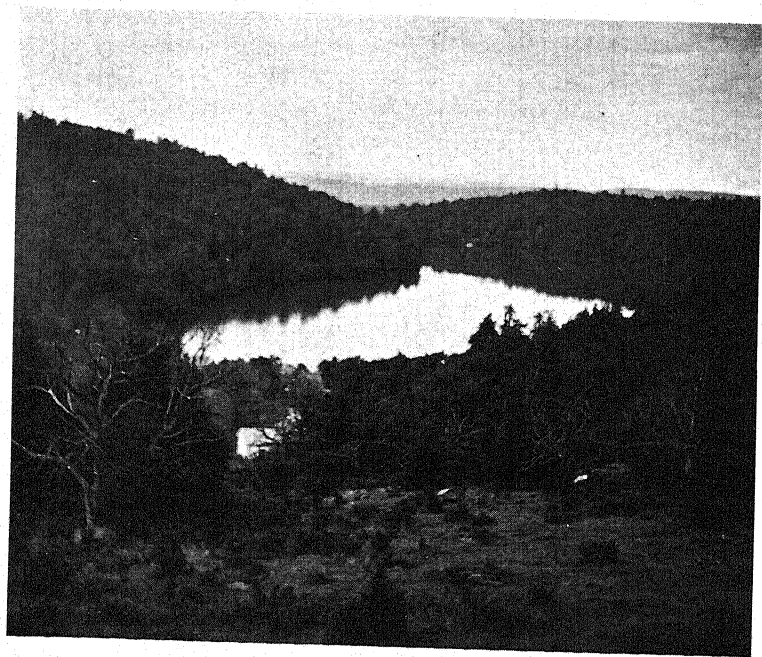


FIG. 1. Mountain Lake.

by the fact that 373 different species were collected during the foray.

A not to be forgotten occasion was that furnished by Mr. John B. Laing, a sympathetic and generous supporter of the Biological Station, who invited the members of the Mycological Society to a picnic on his property at the Cascades of the Little John River, a spot of wild beauty. The approach to this place was via a wood road that passed through woods of white pine or of the broad leaved species of trees and was therefore not unusual for that part of the country, but then suddenly on taking a sharp bend one

entered a beautiful stand of hemlocks, and looking down through this one could see through the lace-work pattern formed by the trees, the beautiful cascades of water falling over a cliff into the depth of a rocky gorge made on one side by the steeply sloping hill-

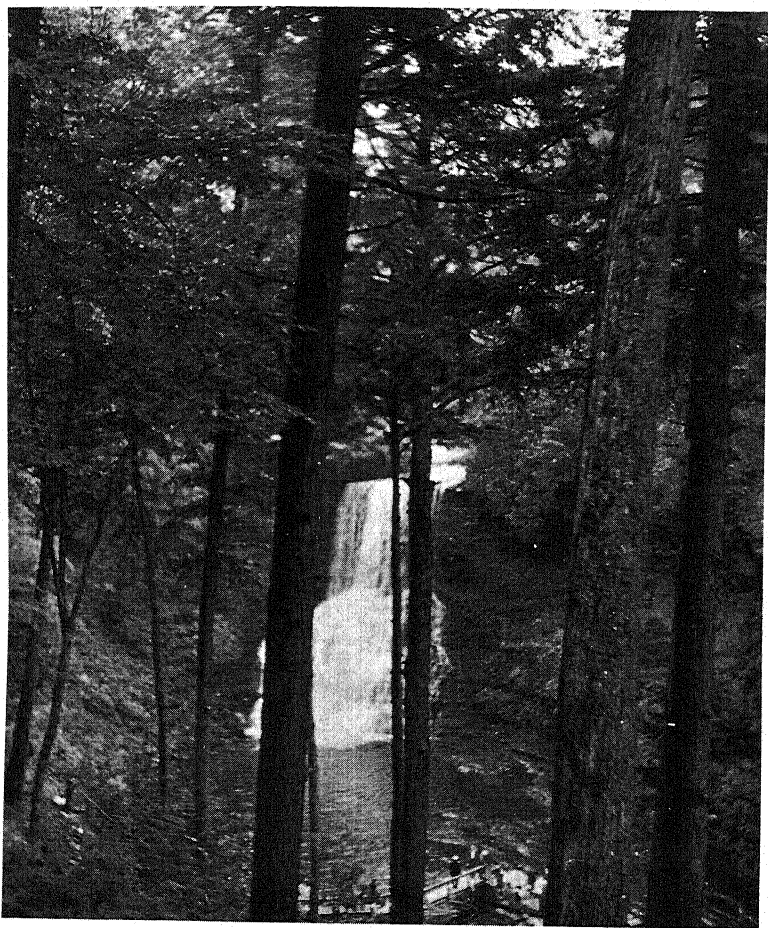


FIG. 2. Cascades of the Little John River. An idea of the height of the falls may be obtained by comparison with the people on the bridge in the foreground.

side covered with trees, and on the other by the almost vertical wall of stratified rock covered with a rich vegetation of bryophytes, ferns, and herbaceous plants that made a lush growth in the humid

atmosphere created by the tumbling waters. In these surroundings, on a rock island in the middle of the stream and not far from the base of the falls, the members of the Society enjoyed an esthetic as well as gastronomic feast. But even in this setting, the collecting instinct came to the fore, and not long after lunch, members could be seen collecting along the less steep side of the gorge. It is certain that all of us who were privileged to visit this

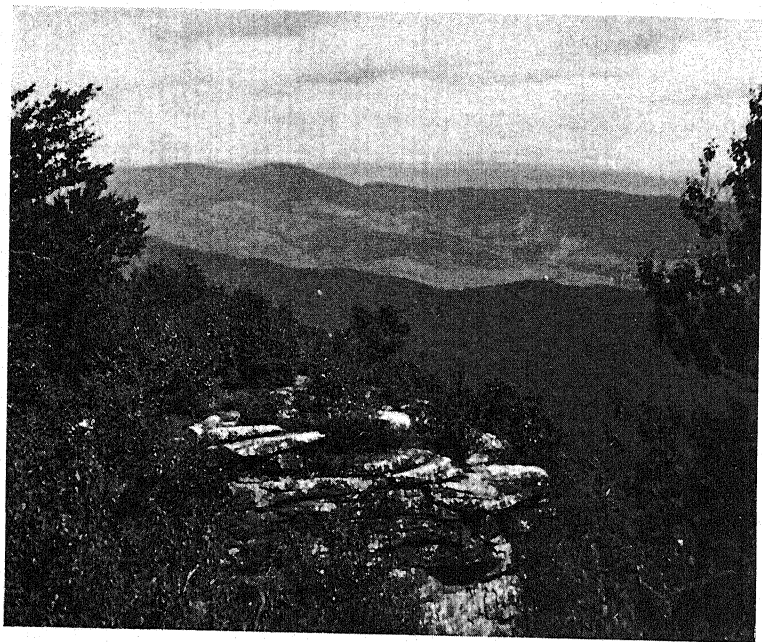


FIG. 3. Looking eastward from Eagle Rock.

place of beauty, greatly appreciated Mr. Laing's hospitality and generosity.

The following day the party was divided in its interests. A portion decided to remain in the vicinity of the Station to carry on with their collecting, while the other part, after lunch, followed the trail above the camp to Eagle Rock and Bald Knob. The collecting on this trip was very good, but scarcely to be compared with the striking views that were obtained from several vantage points on the way to and at the summit of Bald Knob. Eventually the

trail led down to Mountain Lake which was bordered on its eastern shore by a small "forest" of Rhododendron and mountain laurel. This "forest" was well worth visiting and certainly worthy of more intensive collecting, but the thought that kept forcing itself on our minds was what a sight this place must be earlier in the year when the laurels were in full bloom. However, all who went on the trip felt well repaid by the specimens collected and the scenery they had enjoyed.



FIG. 4. Back row: Dr. G. S. Torrey, Mr. Andy Ingalls, Dr. Ivey F. Lewis. Middle row: Mr. Thomas Brown, Mr. Fulton, Miss Hagelstein, Mrs. Robert Hagelstein, Mrs. G. S. Torrey, Miss Overholts, Mrs. H. R. Fulton, Miss Fulton, Mrs. Walter H. Snell, Mrs. W. W. Diehl, Dr. H. R. Fulton, Mr. Thomas. Front Row: Mr. John A. Stevenson, Dr. L. O. Overholts, Dr. Walter H. Snell, Dr. C. L. Shear, Dr. D. H. Linder, Mr. Robert Hagelstein, Miss Edith Cash, Miss Anna E. Jenkins, Dr. W. W. Diehl.

It was the general consensus of opinion that the foray was decidedly well worth while, since not only did it give the members an excuse to get away from their usual haunts, but also furnished them an opportunity to gather in an informal way and be sociable

with kindred souls. For the pleasure and success of the foray, a debt of gratitude is owed to Dr. and Mrs. Ivey Lewis whose genial hospitality and whose keen interest and coöperation made it possible to do so much in so little time. Also many thanks are due to Miss Proffitt who so ably assisted Dr. Lewis, and to Mrs. Feil who saw to it that the members were well fed, and finally Messrs. Andy L. Ingalls, Thomas D. Brown, Walton C. Gregory, and Charles Maphis of the laboratory staff deserve our sincere thanks for their ever willing helpfulness and for guiding us over the various trails that led through the excellent and varied collecting grounds.

The following attended the foray (non-members preceded by an asterisk): Miss Edith Cash, Dr. and *Mrs. W. W. Diehl, *Mr. and *Mrs. Walter H. Snell, Mr. John A. Stevenson, *Mr. Thomas, stein, *Miss Hagelstein, Miss Anna E. Jenkins, Dr. D. H. Linder, Dr. L. O. Overholts and *Miss Overholts, Dr. C. L. Shear, Dr. and *Mrs. Walter H. Snell, Mr. John A. Stevenson, Mr. Thomas, and Dr. and *Mrs. G. S. Torrey.

In making up the list of species collected at Mountain Lake, the writer has, for the sake of brevity, omitted the names of collectors and in their stead has indicated by symbols the herbaria in which the specimens have been deposited. Thus, if anyone should desire to write up a flora of the region involved or of the state of Virginia as a whole, these specimens might be more readily located and additional data obtained from them. The symbols, represented by letters in parenthesis, are as follows:

- (F) = Farlow Herbarium, Harvard University.
- (H) = Herbarium of Robert Hagelstein or of the New York Botanical Garden.
- (O) = Overholts Herbarium or that of Pennsylvania State College.
- (S) = Herbarium of Walter H. Snell or of Brown University.
- (W) = Bureau of Plant Industry, U. S. Department of Agriculture, Washington, D. C.

MYXOMYCETES: *Arcyria cinerea* (Bull.) Pers., (H); *A. denudata* (L.) Wett., (H); *A. digitata* (S.) Rost., (F); *A. globosa* Schw., (F, H, W); *Badhamia rubiginosa* (Chev.) Rost., (H); *Ceratiomyxa fruticulosa* (Muell.) Macbr., (H); *Comatricha typhoides* (Bull.) Rost., (H); *Cribraria purpurca*

Schrad., (H); *Diachea leucopodia* (Bull.) Rost., (H); *Diderma floriforme* (Bull.) Pers., (F); *Diderma testaceum* (Schrad.) Pers., (F, H, W); *Didymium nigripes* (Lk.) Fr., (F, H); *Enteridium Rozeanum* (Rost.) Wing., (F, W); *Hemitrichia serpulula* (Scop.) Rost., (F, H); *H. stipitata* (Mass.) Macbr., (H); *H. vesparium* (Batsch) Macbr., (H); *Leocarpus fragilis* (Dicks.) Rost., (H, W); *Lycogala conicum* Pers., (H); *L. epidendrum* (L.) Fr., (F); *L. exiguum* Morg., (H); *Physarum globuliferum* (Bull.) Pers., (H); *P. leucopus* Lk., (H); *P. nutans* Pers., (F, H); *Trichia contorta* (Ditm.) Rost., (H); *T. favoginea* (Batsch) Pers., (F, H); *T. inconspicua* Rost., (H).

PHYCOMYCETES: *Synchytrium decipiens* Farl. on *Amphicarpa monoica* (L.) Ell., (O, W).

PYRENOMYCETES: *Bertia moriformis* (Tode) Fr. on *Betula lenta* L., (F); *Clypeolella Leemingii* (Ell. & Ev.) Theiss. on *Panax aphylla* L., (F, O, W); *Coccomyces coronatum* (Schum.) DeNot. on *Quercus* sp., (W); *C. dentatus* (Kze. & Schum.) Sacc. on *Rhododendron maximum* L., (O, W); *Cordyceps capitata* (Holmsk ex Fr.) Tul. on *Elaphomyces cervinus* (L. ex Gray) Schlecht., (F); *C. militaris* (L.) Lk., (F, O, W); *Daldinia concentrica* (Bolt.) Ces. & DeNot., (W); *Dimerosporium Galactis* Ell. & Ev. on *Panax aphylla* L., (F); *D. Tsugae* Dearn. on *Tsuga canadensis* (L.) Carr., (F, W); *Elaphomyces cervinus* (L. ex Gray) Schlecht., (F); *Endothia parasitica* (Murr.) And. & And. on *Castanea dentata* (Marsh.) Borkh., (W); *Eutypa spinosa* (Pers.) Nitschke on *Quercus* sp., (W); *Gloniopsis Smilacis* (Schw.) Und. & Earle on *Smilax* sp., (W); *Glonium stellatum* Muhl., (O, F); *Gnomonia Coryli* (Batsch ex Fr.) Awd. on *Corylus rostrata* Ait., (F); *Hypocrea gelatinosa* (Tode) Fr. on *Betula* sp. and *Polyporus* sp. on dead wood, (O, W); *H. lenta* (Tode) Berk. & Br., (W); *H. rufa* (Pers.) Fr. on *Quercus* sp., (W); *Hypoderma commune* (Fr.) Duby on *Smilax* sp., (W); *Hypoxylon caries* (Schw.) Sacc., (W); *H. coccineum* Bull. on *Rhododendron maximum* L., (W); *H. cohaerens* (Pers.) Fr. on *Rhododendron maximum* L., (W); *H. marginatum* (Schw.) Berk., (W); *H. multiforme* Fr. on *Acer* sp., (W); *H. rubiginosum* (Pers.) Fr., (O); *Lasiosphaeria ovina* (Pers.) Ces. & DeNot. on *Betula lenta* L., (F); *Leptosphaeria fusispora* Niessl on *Cimicifuga racemosa* (L.) Nutt., (W); *Microsphaera Alni* (Wallr.) Wint. on *Quercus coccinea* Muench., (W); *Nectria cinnabarina* (Tode) Fr., (W); *N. lactea* Ell. & Morg., (W); *Ophiodothella Vaccini* Boyd, (O); *Peckiiella viridis* (Pers.) Sacc., (O); *Podostroma alutaceum* (Pers.) Atk., (F, O); *Propolis faginea* (Schrad.) Karst., (O); *Rhytisma salicinum* (Pers.) Fr. on *Salix* sp., (F, O, W); *Rosellinia purpureofusca* (Schw.) Ell. & Ev. on *Betula* sp., (W); *R. subiculata* (Schw.) Sacc., (W); *Schizothyrium Gaultheriae* (Curt.) v. Hoehn. on *Gaultheria procumbens* L., (W); *Stictis quercifolia* Cke. & Ell. on *Quercus* sp., (W); *S. radiatus* (L.) Pers., (O, W); *Ustilina vulgaris* Tul. on *Acer rubrum* L., (W); *Venturia Rhododendri* Tengw. on *Rhododendron maximum* L., (W); *Xylaria corniformis* Fr. on *Fagus grandifolia* Ehrh., (W); *X. Cornu-Damae* (Schw.) Berk., (F, O, W).

DISCOMYCETES: *Arachnopeziza arenea* (DeNot.) Sacc. on chestnut burs, (F, W); *A. delicatula* Fckl., (W); *Calycina macrospora* (Peck) Seaver, (W); *Chlorosplenium chlora* (Schw.) Massee on chestnut log, (F, O, S,

W); *Ciboria nebulosa* (Cke.) Seaver, (O); *Coryne sarcoides* (Jacq.) Tul. conidial stage on *Fagus grandifolia* Ehrh., (O, W); *C. urnalis* (Nyl.) Sacc., (W); *Cudonia lutea* (Peck) Sacc., (F, O, W); *Cyathicula coronata* (Bull.) DeNot., (W); *Dermatea brunneo-pruinosa* Zeller on *Rhododendron maximum* L., (W); *Dermatea prunastri* (Pers.) Fr., (F, O); *D. purpurascens* Ell. & Ev. on *Castanea dentata* (Marsh.) Borkh., (O, W); *Geoglossum glabrum* Pers., (O, W); *G. hirsutum* Pers., (W); ?*Godroniopsis querneae* (Schw.) Diehl & Cash, (W); *Helotium citrinum* (Hedw.) Fr., (W); *H. epiphyllum* (Pers.) Fr. on *Acer* sp., (W); *H. scutula* (Pers.) Karst., (W); *Helvella atra* Oed., (W); *Helvella crispa* (Scop.) Fr., (F, O); *H. infula* Schaeff., (O); *Lachnum ciliare* (Schrad.) Rehm, (W); *L. virgineum* (Batsch) Karst., (W); *Lamprospora trachycarpa* (Curr.) Seaver, (W); *Leotia lubrica* (Scop.) Pers., (O, W); *L. lubrica* f. *Stevensoni* (B. & Br.) Mass., (F); *Microglossum rufum* (Schw.) Underw., (W); *Mollisia cinerea* (Batsch) Karst., (W); *Orbilbia xanthostigma* Fr., (W); *Otidea grandis* (Pers.) Mass., (W) or *Otidea leporina* (Batsch) Fckl., (F, O); *Patella albida* (Sch.) Seaver, (F); *P. scutellata* (L.) Morg., (F, O, W); *Paxina hispida* (Schaeff.) Seaver, (F, O, W); *Pezicula acericola* Peck, (O); *P. minuta* Peck on *Viburnum alnifolium* Marsh., (O, W); *P. Rubi* (Lib.) Niessl on *Rubus odoratus* L., (F, W); *Phialea dolosella* (Karst.) Sacc., (O, W); *P. phyllophila* f. *fagicola* Sacc. on *Fagus* leaves, (O, W); *P. scutula* var. *Pteridis* (Feltg.) Sacc. on ?*Pteridium aquilinum* L., (F); *Pseudopeziza Ribis* Kleb. on *Ribes* sp., (W); *Sarcoscypha floccosa* (Schw.) Sacc. on *Hicoria* sp., (S, W); *S. occidentalis* (Schw.) Sacc., (W, ?S); *Spathularia velutipes* Cke. & Farl., (F, O, W).

UREDINALES: *Coleosporium solidaginis* Thuem. on *Aster acuminatus* Michx., (W), on *Solidago Curtisii* T. & G., (W), on *S. rugosa* Mill., (W), *Solidago* sp., (O); *Gymnoconia Peckiana* (House) Trotter on *Rubus allegheniensis* Porter, (F); *Gymnosporangium globosum* Farl. on *Crataegus* sp., (F, W); *Kuchneola uredinis* (Lk.) Arth. on *Rubus allegheniensis* Porter, (F, O, W) and *R. trivialis* Michx., (F, W); *Phragmidium Potentillae* (Pers.) Karst. on *Potentilla canadensis* L., (F); *Puccinia atropuncta* P. & C. on *Amianthium muscaetoxicum* (Walt.) Gray, (F); *P. Cypripedii* Arth. on *Cypripedium parviflorum* Salisb., (W); *P. Heucherae* (Schw.) Diet. on *Tiarella cordifolia* L., (F, O); *P. Menthae* Pers. on *Monarda fistulosa* L., (W); *P. Schedonnardi* Kell. & Swingle on *Muhlenbergia Schreberi* J. F. Gmel., (W); *P. Violae* (Schum.) DC. on *Viola hastata* Michx., (F); *Pucciniastrum Hydrangeae* (B. & C.) Arth. on *Hydrangea arborescens* L., (F, O, W); *P. Myrtilli* (Schum.) Arth. on *Vaccinium erythrocarpon* Michx., (W); *Tranzschelia Pruni spinosae* (DC.) Lindr. on *Prunus* sp. (wild cherry), (W); *Uromyces Hyperici* (Spreng.) Curt., (O); *Uromyces Silphii* (Burr.) Arth. on *Juncus Dudleyi* Wieg., (F).

PROTOBASIDIOMYCETES: *Calocera cornea* (Batsch) Fr., (F, W); *Sebacina incrustans* Pers. ex Tul., (F); *Tremella carneo-alba* Coker on *Diatrype Stigma* (Hoffm.) Fr., (W); *T. frondosa* Fr., (O, W); *Tremellodendron candidum* (Schw.) Atk., (W); *T. cladonia* (Schw.) Burt, (W); *T. palidum* (Schw.) Burt, (F, O); *Tremellodon gelatinosum* Scop., (F, O, W).

THELEPHORACEAE: *Aleurodiscus acerinus* (Pers.) v. Hoehn. & Litsch., (F); *A. candidus* (Schw.) Burt, (O); *A. Oakesii* (Berk. & Curt.) Cke.,

(F, O); *Corticium atrovirens* Fr., (F, O); *C. vagum* Berk. & Curt., (O); *Craterellus cantharellus* (Schw.) Fr., (F, O); *Cyphella capula* f. *flocculosa* Bourd. & Galz. on *Eupatorium* sp., (W); *Exobasidium Vaccinii* Wor., (O); *Hymenochaete rubiginosa* (Dicks.) Lev. on *Quercus* sp., (W); *H. spreta* Peck, (O, W); *H. tabacina* (Sow.) Lev., (O, W); *Hypocninus botryoides* (Schw.) Burt, (O); *H. isabellinus* Fr., (O); *H. ferrugineus* (Pers.) Fr., (O, W); *H. pannosus* (Berk. & Curt.) Burt, (O); *Peniophora coccineofulva* (Schw.) Burt, (O); *Peniophora crenea* Bres., (O); *P. Peckii* Burt, (O); *Solenia fasciculata* Pers., (F); *Stereum Burtianum* Peck, (O); *S. fasciatum* Schw., (W); *S. hirsutum* (Willd.) Fr., (W); *S. rameale* (Schw.) Fr., (O, W); *Thelephora vialis* Schw., (F, O, W).

CLAVARIACEAE: *Clavaria crocea* Pers., (F, W); *C. fusiformis* (Sow.) Fr., (O); *C. Kunzei* Fr., (W); *C. laciniata* Schaeff., (O); *C. mucida* Pers., (F, O); *C. ornatipes* Peck, (F, O); *C. pistillaris* (L.) Fr., (F, O, W); *C. stricta* (Pers.) Fr., (O); *C. subbotrytis* Coker, (F); *Pistillaria clavulata* Ellis, (W); *Typhula filicina* Peck, (F, W).

HYDNACEAE: *Grandinia raduloides* (Karst.) Bourd., (O); *Hydnum adustum* (Bank.) Sacc. & Trott., (O); *H. adustum* Schw., (O); *H. Caput-Ursi* Fr., (O); *H. coralloides* Scop., (F); *H. erinaceum* Bull., (W); *H. repandum* (L.) Fr., (F, O, W); *H. rufescens* (Pers.) Fr., (O); *H. sonatum* (Batsch) Fr., (O); *Odontia bicolor* (A. & S.) Schw., (O); *O. lactea* Karst., (O); *Steccherinum ochraceum* (Pers.) S. F. Gray, (W).

POLYPORACEAE: *Cyclomyces Greenei* Berk., (O, W); *Daedalea confragosa* (Bolt.) Fr., (W); *D. quercina* (L.) Fr., (W); *Favolus alveolaris* (DC.) Quel., (F); *Fistulina hepatica* (Huds.) Fr., (F, W); *Fomes applanatus* (Pers.) Gill., (O, W); *F. connatus* Fr., (F, O, W); *F. fomentarius* (L.) Fr., (O); *F. igniarius* var. *laevigatus* (Fr.) Overh., (O); *F. pinicola* (Schw.) Fr., (O); *Lenzites betulina* (L.) Fr., (O, W); *Polyporus albellus* Peck, (O); *P. cinnabarinus* (Jacq.) Fr., (O, W); *P. ?compactus* Overholts, (S); *P. dichrous* Fr., (O); *P. elegans* (Bull.) Fr., (F, O); *P. fragilis* Fr., (O, W); *P. giganteus* (Pers.) Fr., (O, W); *P. guttulatus* Peck, (F, O); *P. hirsutus* (Wulf.) Fr., (O, W); *P. immitis* Peck, (O); *P. nidulans* Fr., (F); *P. pargamensis* Fr., (W); *P. semipileatus* Peck, (O); *P. (Ganoderma) Tsugae* (Murr.) Overh., (O); *P. versicolor* (L.) Fr., (O, W); *Poria candidissima* Schw., (O); *P. crassa* Karst., (F); *P. semitincta* (Peck) Cke., (F, O, W); *P. versipora* Pers., (F, S).

BOLETACEAE: *Boletinus castanellus* Peck, (F, O, S); *B. pictus* Peck, (O, S, W); *Boletus affinis* Peck, (F, S); *B. alboater* Schw., (O, S); *B. americanus* Peck, (O, S); *Boletus auriporus* Peck, (F); *Boletus badius* Fr., (F, S); *B. bicolor* Frost, (S); *B. castaneus* Bull. ex Fr., (O, S); *B. chrysenteron* Fr., (F, S); *B. cyanescens* Bull. ex Fr., (S); *B. felleus* Bull. ex Fr., (S); *B. gracilis* Peck, (F, S); *B. granulatus* (L.) Fr., (F, O, S); *B. indecensus* Peck, (F, S); *B. miniato-olivaceus* Frost, (F, O, S); *B. ornatipes* Peck, (S); *B. pallidus* Peck, (S); *B. parasiticus* Bull., (F); *B. punctipes* Peck, (O, S); *B. rugosiceps* Peck, (S); *B. scaber* Fr., (F, O, S); *B. separans* Peck, (S); *B. subluteus* Peck, (O, S); *Strobilomyces strobilaceus* (Scop.) Berk., (O, S).

AGARICACEAE: *Amanita bisporiger* Atk., (F, O); *A. Caesarea* (Bull.) Fr., (O); *A. chlorinosma* Peck, (F, O, S); *A. flavoconia* Atk., (F, O, S);

A. mappa Fr., (F); *A. rubescens* Fr., (F, S); *A. solitaria* (Bull.) Fr., (O, S); *A. spissa* Fr., (S); *A. verna* Fr., (S); *Amanitopsis vaginata* var. *fulva* Sacc., (F, O, S); *A. vaginata* var. *livida* Peck, (S); *Armillaria mellea* (Vahl.) Fr., (O, S); *Cantharellus aurantiacus* Fr., (F, O, S, W); *C. cinnabarinus* Schw., (F, O, S); *C. cibarius* Fr., (O); *C. infundibuliformis* (Scop.) Fr., (F, O); *C. tubaeformis* Fr., (F); *Clitocybe clavipes* (Pers.) Fr., (O); *C. illudens* (Schw.) Sacc. (O); *C. laccata* (Scop.) Fr., (O); *C. ochropurpurea* Berk., (F, O, W); *Clitopilus orcellus* Fr., (O); *Collybia albiflavida* (Pk.) Kauff., (F); *C. confluens* Fr., (W); *C. dryophila* (Bull.) Fr., (O); *C. platyphylla* Fr., (F); *C. radicata* (Rehl.) Berk., (O); *C. strictipes* Peck, (O); *Cortinarius armillatus* Fr., (F, O); *C. bolaris* Fr., (O); *C. corrugatus* Peck, (F, O, S); *C. purpurascens* Fr., (F, O); *C. semisanguineus* Fr., (S); *Crepidotus dorsalis* Peck, (F, O); *C. malachius* Berk. & Curt. (F, O); *Flammula polychroa* Berk., (F, O); *Galera tenera* var. *pilosella* Peck, (O); *Hygrophorus borealis* Fr., (O); *H. chlorophanus* Fr., (O); *H. conicus* (Scop.) Fr., (O); *H. coccineus* Fr., (S); *H. marginatus* Peck, (S); *H. miniatus* Fr., (F); *H. psittacinus* (Schaeff.) Fr., (O); *Inocybe hystrix* Fr., (F); *I. lilacina* (Peck) Kauffm., (F, O); *Lactarius camphoratus* (Bull.) Fr., (O); *L. cinereus* Peck, (O); *L. corrugis* Peck, (F); *L. croceus* Burl., (F); *L. deceptivus* Peck, (F, O, S); *L. Gerardii* Peck, (O); *L. lignyotus* Fr., (F); *L. luteolus* Peck, (F); *L. Peckii* Burl., (F, O); *L. pergamenus* (Swartz) Quél., (O); *L. piperatus* (Scop.) Fr., (O); *L. subpurpureus* Peck, (F); *L. theiogalus* Fr., (F, O); *Lepiota ?acutisquamosa* Fr., (S); *L. amianthina* (Scop.) Fr., (O); *L. cristata* Fr., (O); *L. metulisporea* Berk. & Br. sensu Bres., (F); *L. procera* Fr., (S); *L. rugoso-reticulata* Lorin, (O, W); *Marasmius androsaceus* Fr., (F); *M. cohaerens* Fr., (F); *M. confluens* (Pers.) Ricken, (O); *M. dichrous* Berk. & Curt., (F); *M. foetidus* Berk. & Curt., (O); *M. in-stitutus* Fr., (O, W); *M. oreades* Fr., (W); *M. resinosus* Peck, (W); *M. rotula* (Scop.) Fr., (O, W); *M. semihirtipes* Peck, (O, W); *M. siccus* (Schw.) Fr. (F, S, W); *M. subnudus* (Ell.) Peck, (O, S); *Mycena Leaiana* Berk., (F, O); *Omphalia campanella* (Bull.) Fr., (O); *O. fibula* (Bull.) Fr., (O); *Panus stypticus* (Bull.) Fr., (O, W); *Paxillus involutus* Fr., (F); *Paxillus rhodoxanthus* Schw., (F); *Pholiota acericola* Peck, (O); *P. Johnsoniana* Peck, (O); *P. squarrosoides* Peck, (O); *P. subsquarrosa* Fr., (F); *Pleurotus applicatus* Fr., (F, W); *P. ostreatus* Fr., (W); *P. porrigens* (Pers.) Fr., (O); *P. sapidus* Fr. (F, S); *Pluteus cervinus* (Schaeff.) Fr., (O, S); *Psalliota diminutiva* Peck, (F, O); *Psilocybe foeniseii* (Pers.) Fr., (O); *Russula crustosa* Peck, (F, O, S, W); *R. decolorans* Fr., (O); *R. emetica* Fr., (S); *R. flava* Romell, (O, S); *R. foetens* Fr., (F, O, S); *R. fragilis* Fr., (F, S); *R. lactea* Pers., (O); *R. sericeonitens* Kauffm., (O); *R. simillima* Peck, (O); *R. variata* Bann. & Peck, (O); *R. ?violaceus* Quél., (F); *Schizophyllum commune* Fr., (S, W); *Tricholoma sulphureum* Fr., (S); *Trogia crispa* Fr., (W).

GASTEROMYCETES: *Bovista pila* Berk. & Curt., (W); *Calostoma cinnabarina* Desv., (F, O, W); *C. Ravenelii* (Berk.) Mass., (F); *Calvatia cyathiformis* (Bosc.) Morg., (W); *Crucibulum vulgare* Tul., (W); *Cyathus stercoreus* (Schw.) DeToni (W); *C. striatus* Willd., (W); *Lycoperdon atropurpureum* Vitt., (W); *L. Curtisii* Berk., (F); *L. fuscum* Bon., (F);

L. gemmatum Batsch, (O, W); *L. marginatum* Vitt., (F, O); *L. pyriforme* Schaeff., (F); *L. subincarnatum* Peck, (W); *Scleroderma aurantia* (Vail.) Pers., (O, W); *Sphaerobolus stellatus* Tode, (S, W).

FUNGI IMPERFECTI: *Anthina pallida* DeBy on *Rhododendron maximum* L., (W); *Cephalosporium Acremonium* Cda. on *Lycogala epidendrum*, (F); *Cercospora ageratoides* Atk., (O); *C. clavata* (Gerard) Cke., on *Asclepias* sp., (F); *C. smilacina* Sacc., (O); *C. Violae* Sacc., (W); *Cercospora cana* (Pass.) Sacc., on *Erigeron canadensis* L., (W); *Cladosporium* sp. on *Rubus odoratus* L., (W); *Cryptostictis Mariae* (Pk.) Sacc. on *Rhododendron maximum* L., (W); *Cylindrosporium acerinum* (Peck) Dearn. & House, (O); *C. saccharinum* Ell. & Ev., (W); *Darlucia Filum* (Bivon.) Cast. on *Phragmidium Potentillae* (Pers.) Karst., (F), on *Puccinia Schendonardi* Kell. & Swingle, (W), on *P. Menthae* Pers., (W), on *Uromyces Silphii* (Burr.) Arth., (F), host not stated, (O); *Dendrodochium compressum* Ell. & Ev., (F, O, W); *Discosia rugulosa* B. & C. on *Carya* sp., (W); *Entomosporium maculatum* Lev. on *Amelanchier* sp., (W); *Fusicladium Robiniae* Shear on *Robinia Pseudo-Acacia* L., (W); *Gelatinosporium betulinum* Peck on *Betula lenta* L., (O, W); *Gonatobotryum maculicola* (Wint.) Sacc. on *Hamamelis virginiana* L., (F, O, W); *Marssonina Martinii* Sacc. & Ell. on *Quercus* sp., (W); *M. ochroleuca* Berk. & Curt. on *Castanea dentata* (Marsh.) Borkh., (W); *Myocopron Smilacis* (DeNot.) Sacc. on *Smilax* sp., (W); *Pestalotia macrotricha* Kleb. on *Rhododendron maximum* L., (W); *Pestalotia* sp. on *Osmunda* sp., (W); *Phoma castanea* Peck, (O); *Phyllosticta minutissima* Ell. & Ev. on *Acer* sp., (F); *P. vagans* Peck on *Convolvulus majalis* L., (W); *Polythrincium trifolii* (Kze.) (O, W); *Ramularia Oxalidis* Farl. on *Oxalis Acetosella* L., (W); *Septoria Rubi* West., (W); *S. Rubi* var. *pallida* Ell. & Holway, (O); *Sphaeronema acerina* Peck, (O); *Sporocybe Azaleae* (Pk.) Sacc. on *Rhododendron maximum* L., (W); *Sporodesmium concinnum* Berk., (F, O); *S. peziza* Cke. & Ell. on *Castanea dentata* (Marsh.) Borkh., (W); *S. polymorphum* Cda., (F); *Stemphylium* sp. on *Rhododendron maximum* L., (W); *Stephanoma strigosum* Wallr. on *Lachnea hemispherica*, (W); *Stilbum giganteum* Peck on *Acer*, (F, W); *Streptothrix atra* Berk. & Curt. on *Fagus grandifolia* L., (W); *Thyrsidium botryosporium* Mont. on *Fagus grandifolia* L., (F).

In addition to the foregoing species, Dr. Walter H. Snell collected the following in Blacksburg, Virginia: *Clitocybe ochrosperma* Berk., (S); *Psalliotia sylvatica* Fr., (S); *Boletus Betula* Schw., (S); *B. erythropus* Fr., (S).—DAVID H. LINDER.

MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOL. XXIX

JULY-AUGUST, 1937

No. 4

MICROAEROPHILIC STRAINS OF ACTINOMYCES ISOLATED FROM TONSILS

C. W. EMMONS

(WITH 7 FIGURES)

The most familiar type of actinomycosis in man is that involving the jaw. A disease essentially like that in man is not uncommon in cattle and is known as "lumpy jaw." The disease is not contagious and there appears to be little danger in contact with men or animals that have the infection. Nevertheless, when once acquired, it is very difficult to cure. It is characterized externally by swelling of the jaw and a hard board-like induration, and histologically by destruction of tissues with formation of granulation tissue. Pus, which is discharged through sinuses, contains the so-called "sulphur granules." These are composed of cellular debris and fungus hyphae. The latter are arranged radially and they terminate peripherally in club-like structures which are sheaths of deposited material (FIG. 7). The fungus does not respect anatomical boundaries but spreads by slow extension of the lesion to contiguous tissues.

In another clinical type of actinomycosis the abdominal organs are involved. In these cases the primary lesion is often in the appendix. Pulmonary actinomycosis also occurs. Meningitis and a generalized infection are rare manifestations of the disease. These types of actinomycosis, while clinically unlike in most respects, have a common etiology. All are caused by *Actinomyces*

[MYCOLOGIA for May-June (29: 273-375) was issued June 1, 1937]

bovis. There are, in addition, other clinical types of the disease caused by other species of *Actinomyces*.

Actinomyces bovis is a microaerophilic species, difficult to maintain in culture, where it appears as a delicate branching mycelium which breaks up very readily into Gram positive *Bacillus*-like fragments. It does not form spores and it bears little resemblance to those species commonly found in the soil. It probably does not propagate in the soil, although the assumption that it does do so has been a common source of error in text-book treatments of the subject. It has been assumed that cattle become infected while grazing upon grass, hay, stubble, etc., upon which the organism was present. It was likewise believed that men acquired the parasite through the bucolic habit of chewing stems of grass, straw, twigs, etc.

This misconception is probably due to the perpetuation of an old error concerning the etiology of the disease. The organism was first described and named by Harz⁴ in 1877 on the basis of material in infected tissue. Early attempts to obtain cultures were not successful, but in 1891 Bostroem¹ made a large number of cultures, in a few of which an aerobic species of *Actinomyces* grew. He believed this to be the etiologic agent of the disease, and applied to it the name given by Harz. This fungus resembled the forms common in soil, and was probably a saprophyte with which a small number of his cultures were contaminated. In the same year Wolff and Israel¹⁰ planted material from actinomycosis in anaerobic cultures and obtained a fungus which corresponds to the microaerophilic species now ordinarily obtained from the disease and recognized as its etiologic agent. Nevertheless, many authors continue to attribute the disease to the aerobic form described by Bostroem. If his fungus, similar to the common soil forms, were actually the etiologic agent, it would be reasonable to look for it on straw and similar materials. The microaerophilic species isolated by Wolff and Israel, however, should probably be sought elsewhere.

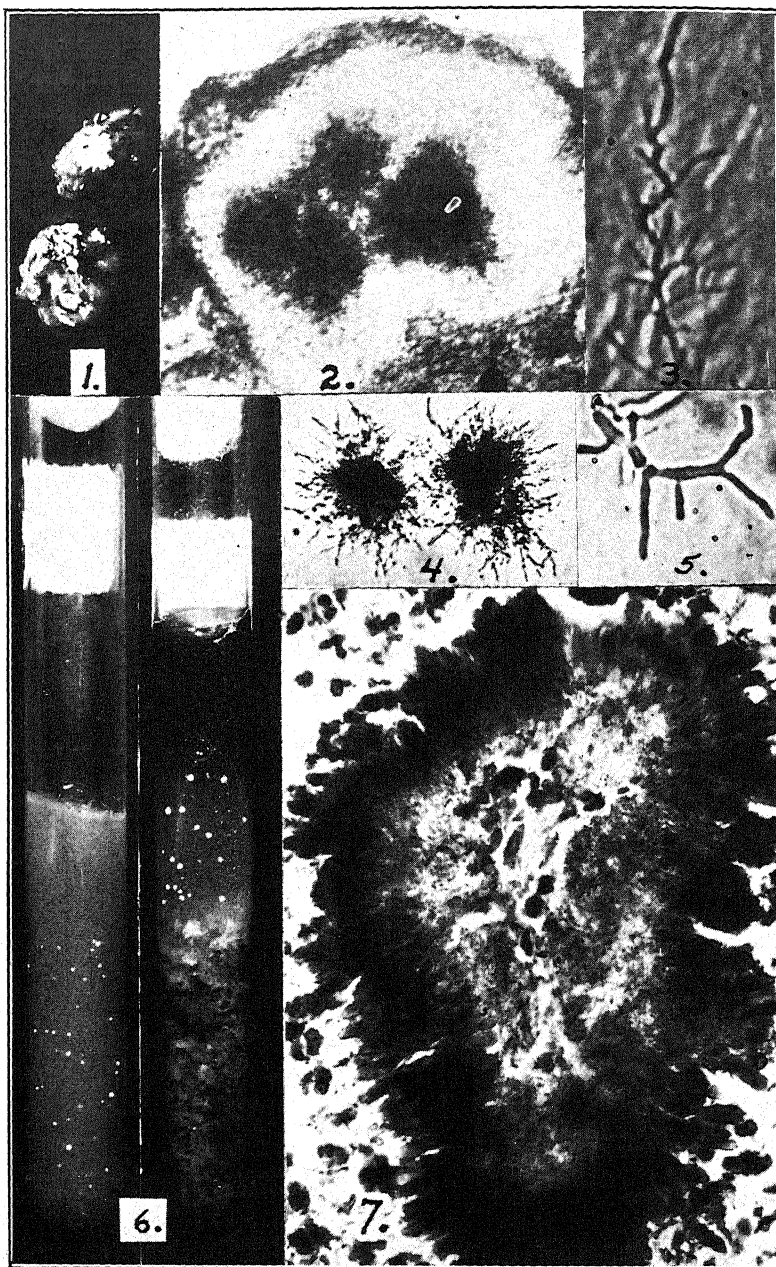
An organism which resembles the one obtained from clinical actinomycosis is actually present in the mouth. Lord^{5,6} in 1910 found such a fungus in and about carious teeth and in the crypts of the tonsils of persons who did not have actual actinomycosis.

In a later paper ⁷ he reviewed this work. Lord and Trevett ⁸ recently duplicated these findings. Naeslund ⁹ in 1931 reported finding an organism indistinguishable from *A. bovis* in the normal mouth. Both Lord and Naeslund produced experimental lesions in animals.

During a study of *Actinomyces* ² from various sources, carried out two years ago, a microaerophilic organism was isolated from tonsils. This strain resembled those from clinical actinomycosis and a further search for similar strains was planned and carried out. In the latter study tonsils were obtained from a series of 100 consecutive tonsillectomies performed in the Presbyterian Hospital, Santurce, Puerto Rico.³ These were taken to the laboratory and dissected. Tiny granules were found in the crypts of many of them. These granules were from microscopic size up to two or three millimeters in diameter (FIG. 1). They were cheesy in consistency and were made up of cellular debris and various microorganisms. In 47 of the pairs of tonsils one or more granules were found which were in part composed of hyphae of *Actinomyces*. The fungus was identified first by examining a portion of the granule crushed under a cover slip. In such preparations it appeared as a network of hyaline interlacing filaments (FIG. 2). If the fungus was found the cover was slipped off and the smear stained by Gram's method. The stained smear showed both long filaments and diphtheroid elements resulting from the fragmentation of the hyphae. The remaining portion of a positive granule was used to prepare cultures.

Cultures were made by mixing the inoculum thoroughly into deep unslanted tubes of melted dextrose veal infusion agar. These were incubated at 37° C. After 4 or 5 days they were examined and isolated colonies which appeared to be those of *Actinomyces* were withdrawn with sterile pipettes, part of the colony being examined for identification and the remainder used for making subcultures (FIG. 6).

Under reduced oxygen tension *Actinomyces* was observed in cultures made from 23 per cent of the cases, and strains were obtained in pure culture from 10 pairs of tonsils. The low percentage of pure cultures is explained by the difficulty of getting



FIGS. 1-7. Actinomyces from tonsils.

the fungus to grow at all, and by the preponderance of several other more rapidly growing microaerophilic organisms.

In none of these tonsils was there any marked cellular reaction to the presence of the *Actinomyces*-containing granules, and in none was there clinical actinomycosis. These were not cases of actinomycosis of the tonsil. That condition has been reported in medical literature but it is rare. The fungus, however, seems to be identical with the one isolated from clinical actinomycosis. It resembles *A. bovis* in morphology (FIGS. 3-5), in staining properties, in rate of growth, and in oxygen requirements (FIG. 6). Its pathogenicity for animals has not yet been properly tested. Experiments so far performed with these strains of the fungus indicate that it has a low degree of virulence. In this respect, also, it corresponds to strains from clinical actinomycosis since it is difficult to produce that disease experimentally in animals. Even in cattle where the disease occurs naturally, it is difficult to transmit the infection either by using cultures or by direct transfer of pus from an infected to a healthy animal. In this, as in some other mycoses, the fungus apparently requires special conditions before it can become established as a pathogen in animal tissue.

These findings, and those previously reported by Lord and by Naeslund, indicate that many people harbor in the normal mouth an organism which may be carried throughout the life of the individual as a harmless saprophyte, but which, under appropriate circumstances, can become a virulent pathogen. The onset of maxillary actinomycosis may follow the trauma incident to extraction of an infected tooth. The tonsillar granules are constantly forming in the crypts, and periodically some slip out into the throat. If they are swallowed, the great majority probably pass uneventfully through the digestive canal. It is probable, however, that many cases of abdominal actinomycosis have resulted from the lodgement and subsequent growth in the appendix of such a granule.

REFERENCES

1. **Bostroem, O.** Untersuchungen über die Aktinomykose des Menschen. Beitr. Path. Anat. Allg. Path. 9: 1-240. 1891.
2. **Emmons, C. W.** *Actinomyces* and actinomycosis. Puerto Rico Jour. Pub. Health Trop. Med. 11 (1): 63-76. 1935.
3. —. Strains of *Actinomyces bovis* isolated from tonsils. Puerto Rico Jour. Pub. Health Trop. Med. 11 (4): 720-727. 1936.
4. **Harz, C. O.** In Bollinger, O. Ueber eine neue Pilzkrankheit beim Rinde. Centralbl. Med. Wissensch. 15: 481-485. 1877.
5. **Lord, F. T.** A contribution to the etiology of actinomycosis. Boston Med. Surg. Jour. 163: 82-85. 1910.
6. —. The etiology of actinomycosis. The presence of *Actinomyces* in the contents of carious teeth and the tonsillar crypts of patients without actinomycosis. Jour. Am. Med. Assoc. 55: 1261-1263. 1910.
7. —. The etiology, pathogenesis, and diagnosis of actinomycosis. Med. Clin. N. Am. 16: 829-844. 1933.
8. **Lord, F. T. & Trevett, L. D.** The pathogenesis of actinomycosis. Recovery of actinomyces-like organisms from the normal mouth. Jour. Infect. Dis. 58: 115-120. 1936.
9. **Naeslund, Carl.** Experimentelle studien über die ätiologie und pathogenese der Aktinomykose. Acta Path. Microbiol. Scand. Suppl. VI. 8: 1-156. 1931.
10. **Wolff, Max & Israel, James.** Ueber Reincultur des *Actinomyces* und seine Uebertragbarkeit auf Thiere. Archiv Path. Anat. Physiol. Klin. Med. (Virchow) 126: 11-59. 1891.

EXPLANATION OF FIGURE

Fig. 1, two tonsils, upon the surfaces of which appear several cheesy granules which originated in the tonsillar crypts and are made up largely of *Actinomyces*; 2, a crushed unstained granule showing the interlacing filaments of *Actinomyces* ($\times 150$); 3, the branching hypha of *Actinomyces bovis* ($\times 900$); 4, colonies of *Actinomyces* on the surface of a plate culture incubated anaerobically ($\times 150$); 5, hypha of *Actinomyces* (oil); 6, colonies of *Actinomyces* growing only below the surface of dextrose veal infusion agar, and below a vaseline seal in chopped meat broth; 7, stained section of a "sulphur granule" from a case of clinical actinomycosis.

PHOTOTROPIC RESPONSE OF PERITHECIAL NECKS IN NEUROSPORA

MYRON P. BACKUS

(WITH 3 FIGURES)

The phenomena recorded in this note first came to the attention of the writer rather accidentally, in the course of some cultural studies on the well-known ascomycete *Neurospora sitophila*. Plates bearing immature perithecia had been set away on a shelf facing a window in the laboratory. When these were examined some days later, ascospores were being discharged; and in certain of the plates on which the arrangement of the ascocarps was peculiar, it was seen from the design of the spore deposit that the spores had been shot in the direction of the window.

The unusual opportunity afforded in the heterothallic forms of *Neurospora* for localizing the development of perithecia at will, by utilizing the spermatiation or conidiation technique worked out by Dodge (2, 3), made it possible to set up an experiment demonstrating in a rather spectacular fashion that the perithecia are sensitive to light.

Petri dishes of two per cent corn meal agar were inoculated with a non-conidial "A" strain of *Neurospora sitophila* obtained originally from Dr. Dodge. After three days' incubation the mycelium had grown across the plate, and thousands of minute sclerotial bodies (incipient perithecia) dotted the surface. From a fresh culture of a "B" conidial strain a suspension of conidia was prepared and the suspension painted over the surface of the "A" cultures with a sterile camel's hair brush. Wherever the spores were applied the "sclerotial" bodies promptly developed into normal perithecia. Plates with ascocarps distributed in all sorts of designs were thus prepared. The cultures were set into a blackened box where light was admitted from one side only. In some instances the cultures were placed here immediately after conidiation, and in others as late as the onset of spore delimitation

in the asci. In any case once placed in position they were left undisturbed until the spores had been discharged. The results were always fundamentally the same. It was found to be quite satisfactory to place the cultures in the box a day or two after conidiation, and there was no difference in the response whether constant illumination was supplied or whether sunlight from a nearby window was the only light source.

Figures 1 and 2 illustrate the result inevitably obtained. Whatever the design of the perithecia on the plate, a shadow-like image of that design, consisting of a heavy deposit of ejected ascospores,



FIG. 1. Portion of a plate culture, showing perithecia of *Neurospora sitophila* distributed in the form of letters, and the shadow-like image consisting of a heavy deposit of ascospores on the agar surface. Light was admitted to the culture from the direction indicated by the arrow.

was formed on the surface of the agar, approximately fifteen millimeters from the ascocarps and in the direction of the open side of the blackened box.

Examination of the cultures under a binocular microscope revealed that practically all the fruiting bodies had their necks bent in one direction—that from which the light came (FIG. 3). In cultures incubated in the dark or in a location where light reaches them from various directions the beaks normally grow upright or are oriented irregularly; and a large proportion of the spores are ejected against the petri dish cover. In the tests conducted, no spores were found on the covers; and the relatively sharp outline of the spore deposit shows not only that the spores are shot distinctly toward the light but also that the ejection force must be remarkably uniform in the case of all the asci. We conclude from

the experiments that the perithecial necks of *Neurospora sitophila* are positively phototropic.

There have been numerous accounts of phototropic responses shown by fungi. In fact, there are probably no examples of

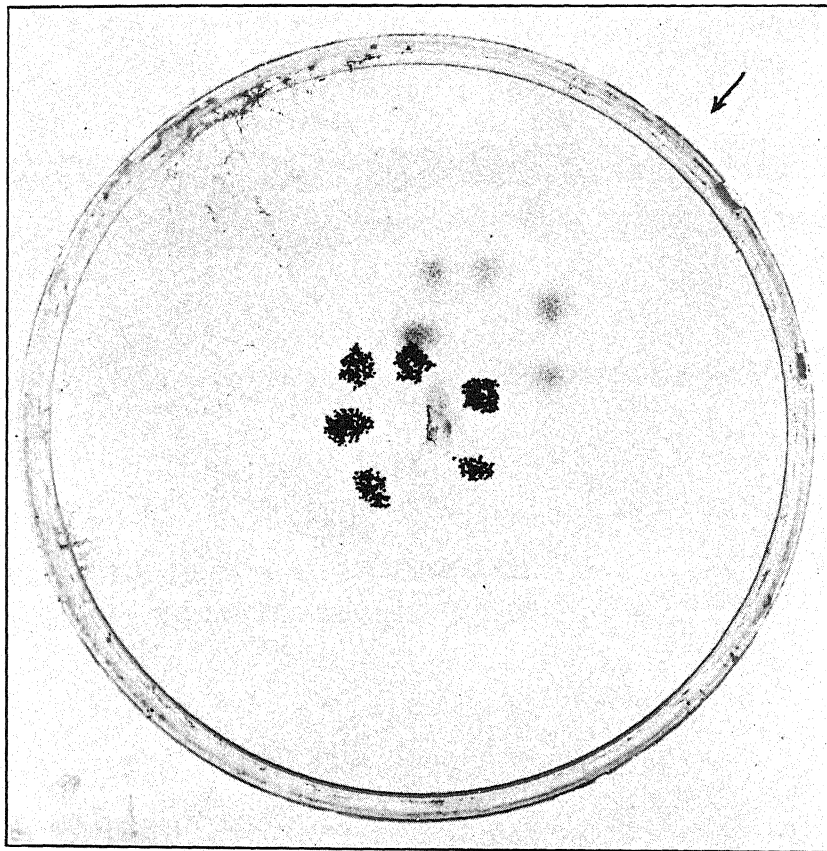


FIG. 2. Petri dish culture, showing essentially the same features illustrated in figure 1, but with a different design of perithecia and spore deposit. The arrow at the upper right indicates the direction from which the light came in this case.

heliotropism in the plant kingdom more remarkable than those displayed by the well-known zygomycete *Pilobolus*. In the ascomycetes interesting responses to light have been recorded in the case of various groups. Norton *et al.* (4) reported that the apothecia of certain species of *Sclerotinia* are phototropic. Bul-

ler, who has worked extensively with tropisms in the fungi, points out that the asci of *Ascobolus* are positively heliotropic and mentions examples in the Sordariaceae where the perithecial necks

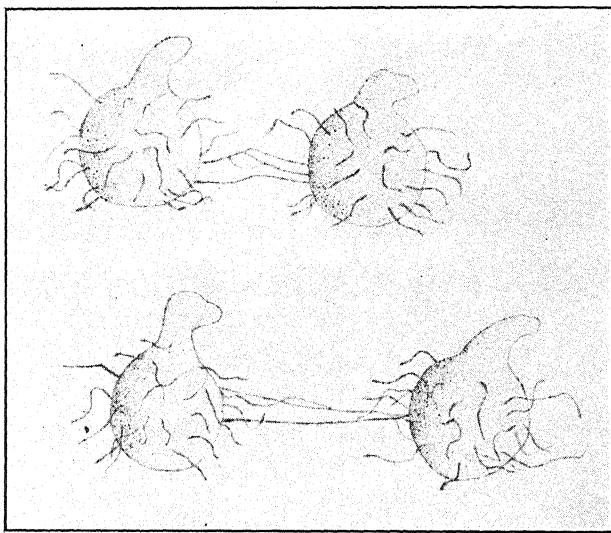


FIG. 3. Drawing of four perithecia from plates similar to those shown in figures 1 and 2, showing the bending of the necks of the ascocarps toward the light, which here came from the right.

respond by bending toward the light (1). It appears to the writer, however, that there is no case in the ascomycetes where it is possible to demonstrate phototropism more easily or more spectacularly than in *Neurospora sitophila*.

DEPARTMENT OF BOTANY,
UNIVERSITY OF WISCONSIN,
MADISON, WISCONSIN

LITERATURE CITED

1. Buller, A. H. Reginald. Researches on fungi. 1: 75, 121, 1909; 5: 103, 1933. Longmans, Green and Co., London.
2. Dodge, B. O. The non-sexual and the sexual functions of microconidia of *Neurospora*. Bull. Torrey Club 59: 347-360. 1932.
3. Dodge, B. O. & Marjorie E. Swift. A simple way to demonstrate sexual reproduction in the bakery mold. Torreyia 33: 31-37. 1933.
4. Norton, S. B. S., W. N. Ezekiel, & R. A. Jehle. Fruit-rotting Sclerotinias. I. Apothecia of the brown-rot fungus. Md. Agr. Exp. Sta. Bull. 256, 32 pp. 1923.

FIRST CANADIAN RECORD OF ALEURO- DISCUS SUBCRUENTATUS¹

MILDRED K. NOBLES

(WITH 7 FIGURES)

A species of *Aleurodiscus*, collected by Mr. C. G. Riley, on the bark of living *Picea glauca* Voss. in Gaspé county, P. Q., on August 8, 1936, was identified, with the aid of Bourdot and Galzin's (1927) key, as *Aleurodiscus scutellatus* Litsch. This determination was verified by Dr. V. Litschauer, who very kindly examined a portion of the specimen. It was recognized that the fungus had many of the characters of *Aleurodiscus subcruentatus* (Berk. & Curt.) Burt as described by Burt (1926) and, through the kindness of Dr. D. H. Linder, a fragment of the type material of the latter species was obtained from the Farlow Herbarium. It was examined and compared with an authentic specimen of *Aleurodiscus scutellatus* Litsch. and with the Gaspé material, and all three were found to be in perfect agreement in both macroscopic and microscopic characters, that is, *Aleurodiscus scutellatus* Litsch. is identical with *Aleurodiscus subcruentatus* (Berk. & Curt.) Burt. Since the latter name has priority as will be shown, the Gaspé material has been labelled *Aleurodiscus subcruentatus* (Berk. & Curt.) Burt. It thus becomes the first record of this fungus in Canada, so far as the writer is aware.²

Aleurodiscus subcruentatus has been recorded only rarely and from widely separated localities. The first collection, made in

¹ Contribution No. 493 from the Division of Botany, Experimental Farms Branch, Department of Agriculture, Ottawa, Canada.

² After this paper had been accepted for publication, Professor H. S. Jackson informed the author that two additional collections of *Aleurodiscus subcruentatus* were in the University of Toronto Herbarium. These had been collected by Dr. L. E. Wehmeyer, who has very kindly granted permission to include the records here. One specimen (77) was collected on living *Picea* sp., Brookside, Colchester county, Nova Scotia, July 26, 1929; the other (77a) was collected on a standing conifer, Salmon River, Colchester county, Nova Scotia, July 14, 1931. These were identified as *Aleurodiscus scutellatus* Litsch. by M. A. Donk.

Japan by members of the U. S. Pacific Exploration Expedition, was described in 1858 by Berkeley and Curtis, who, on the basis of morphological characters only, named it *Stereum subcruentatum*. As such it was listed by Saccardo (1888, p. 567). It was not until after the publication of his monograph on the genus *Aleurodiscus* in 1918 that Burt received American gatherings of *Stereum subcruentatum*. He listed it among the species excluded from the genus *Stereum*, in his treatise on that group (1920), and there published the new combination *Aleurodiscus subcruentatus* (Berk. & Curt.) Burt, but gave no further description until his supplement appeared (1926).

Meanwhile Litschauer (1926) had specimens of a species of *Aleurodiscus* from the North Tyrolean Alps and from China, and, finding no description of it in either American or European literature, described it under the name *Aleurodiscus scutellatus* Litsch. The present study has shown that this is identical with *Aleurodiscus subcruentatus* (Berk. & Curt.) Burt, and since the latter name was published in 1920, six years earlier than Litschauer's publication, *Aleurodiscus subcruentatus* (Berk. & Curt.) Burt has priority.

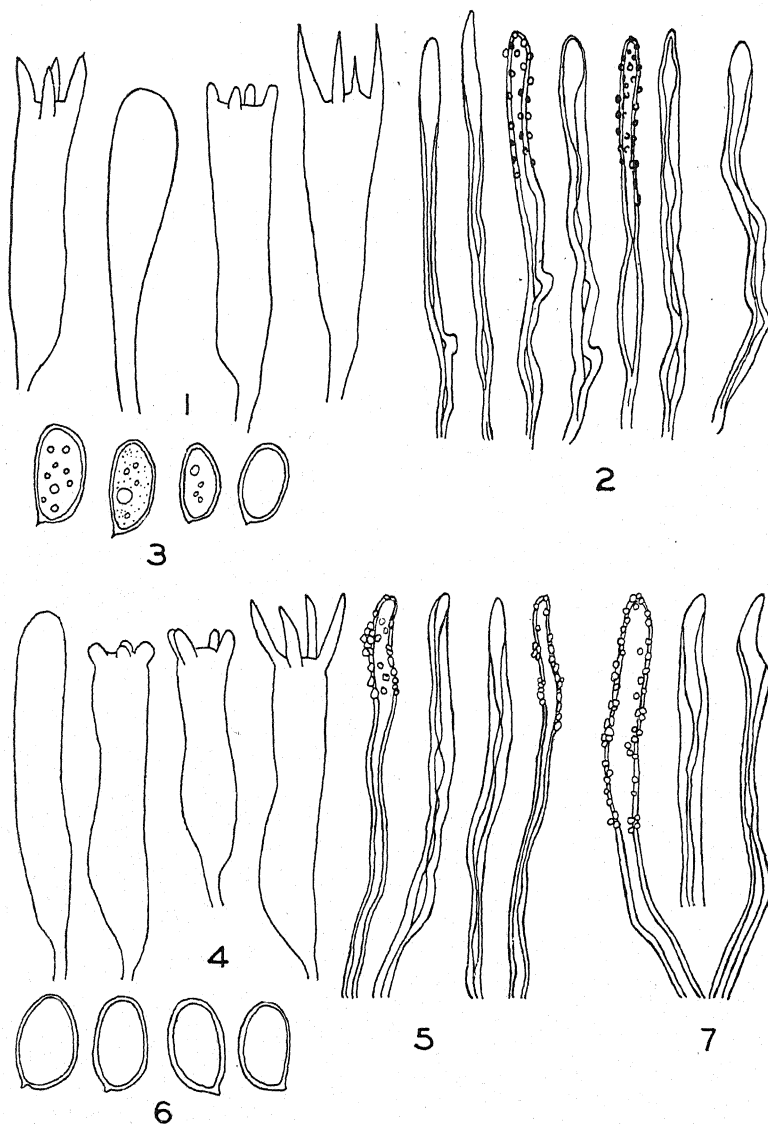
Since Burt's description is rather incomplete, and Litschauer's excellent one is not readily available in America, a detailed description of the fungus, based on earlier descriptions and the author's observations, is given here.

- ALEURODISCUS SUBCRUENTATUS (Berk. & Curt.) Burt, Ann. Mo. Bot. Gard. 7: 237. 1920; Zeller, Mycologia 14: 179. 1922; Burt, Ann. Mo. Bot. Gard. 13: 308. 1926.
Stereum subcruentatum Berk. & Curt. Proc. Am. Acad. 4: 123. 1858; Sacc. Syll. Fung. 6: 567. 1888.
Aleurodiscus scutellatus Litsch. Österr. Botan. Zeitschr. 75: 48. 1926; Pilát, Bull. Soc. Myc. Fr. 42: 111. 1926; Pilát, Ann. Myc. 24: 210. 1926; Bourdot & Galzin. Hym. Fr. 331. 1927.

ILLUSTRATIONS: Litschauer, Pilát (1926 a).

TYPE: in Farlow Herbarium.

Fructification small, orbicular 0.2–1.5 cm. in diameter, resupinate with margin free and inrolled, or attached only at vertex, drying



FIGS. 1-7. 1-3, *Aleurodiscus scutellatus*, after Litschauer, 1, basidia; 2, paraphyses; 3, spores. 4-6, *Aleurodiscus subcruentatus* from a collection on *Picea sitchensis* from Requa, California, collected by E. E. Hubert, communicated by J. R. Weir, 9946 (Mo. Bot. Gard. Herb. 56229), identified and cited by Burt (1926), 4, basidia; 5, paraphyses; 6, spores. 7, *Aleurodiscus subcruentatus* from type material of Burt (Farlow Herb.), paraphyses. $\times 500$.

hard and brittle, but readily soaking up to a pliable leathery texture; upper surface cartridge-buff to Tilleul-buff (Ridgway), covered with short white hairs, somewhat felt-like; hymenium cartridge-buff to pinkish-buff, even, pulverulent; in section 400–1000 μ , somewhat colored, composed of hyphae growing out from the point of attachment, but becoming erect in body of sporophore; hyphae mostly thick-walled, with narrow and irregular lumen, slightly colored and giving color to the fructification, usually incrustated, 2.5–4.5 μ in diameter, but with a few hyphae, especially near the substrate, thin-walled, occasionally nodose-septate, colorless, not incrustated 3–4.5 μ in diameter; paraphyses contorted, with wall irregularly thickened, so that outline and lumen are irregular, frequently thin-walled at apex, or uniformly thick-walled and incrustated, 4.5–7 μ in diameter (FIGS. 2, 5, 7); basidia long-clavate, 40–60 \times 12 μ , bearing four sterigmata which are finally pointed and up to 16 μ long (FIGS. 1, 4); spores broadly ellipsoid, flattened on one side, with apiculus at base of that side, thick-walled, colorless or slightly yellowish, contents turning blue with iodine, 13.5–22 \times 8–16 μ (FIGS. 3, 6).

HABITAT: *Abies grandis* Lindl.; *Picea glauca* Voss.; *Picea sitchensis* Carr.; *Pinus montana* Mill.; *Pseudotsuga taxifolia* Brit.; *Tsuga Sieboldii* Carr.; undetermined coniferous tree.

DISTRIBUTION: California, Oregon, U. S. A.; Gaspé county, P. Q., Canada; Yunnan Province, China; Japan.

Litschauer, who examined the fungus in fresh condition, notes that it is waxy to fleshy, drying leathery, and that the hymenium is at first clear gray-green to yellow-brown at the margin, later becoming grayed. He also observed that the hymenial surfaces of larger fructifications become cracked in age.

In conclusion the author wishes to express her sincere gratitude to Dr. V. Litschauer for his kindness in examining the collection from Gaspé, to Dr. D. H. Linder for his generosity in allowing her to examine the type material of *Aleurodiscus subcruentatus* and authentic material of *Aleurodiscus scutellatus* from the Farlow Herbarium, and to Dr. C. W. Dodge for specimens of *Aleurodiscus subcruentatus* from the Missouri Botanic Gardens Herbarium.

DIVISION OF BOTANY,
CENTRAL EXPERIMENTAL FARM,
OTTAWA, ONTARIO

LITERATURE CITED

- Bourdot, H. & Galzin, A. Hyménomycètes de France. Marcel Bry. Sceaux. 1927.
- Burt, E. A. Thelephoraceae of North America. XII. *Stereum*. Ann. Mo. Bot. Gard. 7: 81-238. 1920.
- . Thelephoraceae of North America. XV. Conclusion, with supplement and general index. Ibid. 13: 173-354. 1926.
- Litschauer, Viktor. Über eine neue *Aleurodiscus* Art. Österr. Botan. Zeitschr. 75: 47-49. 1926.
- Pilát, Albert. Les Agaricales et Aphyllophorales des Carpathes Centrales. Bull. Soc. Myc. Fr. 42: 81-120. 1926 a.
- . Monographie der mitteleuropäischen Aleurodiscineen. Ann. Myc. 24: 203-230. 1926 b.
- Saccardo, P. A. Sylloge Fungorum 6: 567. 1888.
- Zeller, S. M. Contributions to our knowledge of Oregon fungi. I. Mycologia 14: 173-199. 1922.

NOTES ON THE MYCETOZOA—I

ROBERT HAGELSTEIN

In our travels during the season of 1936, we covered over 6,000 miles in the search for Mycetozoa through the mountains from northern Maine to southern Virginia. More than 1,200 fruitings were found. As was to be expected, nearly all were representative of the more than a hundred common species; but among the collections were many interesting phases, and more than a dozen species rarely found and about which little appears in the American literature. It is about those that I will give my impressions in the following notes.

I have always admired the splendid work that the Listers, father and daughter, have done in the taxonomic treatment of the Mycetozoa. Continued for over half a century, their researches with subsequent interpretations and opinions must be given the respect that they deserve. With the large amount of material from all parts of the world, larger than any that has passed through other hands, and with the knowledge gained by constant, careful, and competent observations, their conclusions cannot be lightly contradicted. I know, however, that certain species, and others with varieties and phases which may be said to be distinctively North American, have not been given sufficient consideration by European students; not because of their unwillingness to do so, but because we do not have the collectors who will get out and find them in necessary numbers. They are here if we look for them. We do not realize the immense possibilities that lie in our boundless woodland, as compared with the limited collecting possibilities in England and other parts of Europe.

It is with these thoughts in mind that I intend to continue explorations, sending interesting collections to our European friends, and placing numbered specimens in the Herbarium of The New York Botanical Garden, so that the students of the future may also study them.

I deprecate the practice of publishing lists of species from particular localities and including therein rare or unusual forms without describing the characters upon which the determinations were based, no matter who made them. Such omissions make the records valueless. Several years ago, I saw a local collection and the names accompanying the specimens—which may have been intended for publication—and it was amusing to note the unusual names that had been attached to very ordinary species. Determinations of unusual, little known, or intermediate forms are often very difficult for students who have a wide experience in material collected and studied, and then, like justices in a high court, the able jurists may not agree.

As usual, I have been assisted in the field work by my associates Mr. Joseph H. Rispaud and Mr. John D. Thomas, to whom my gratitude is due. The plural pronoun will be used when more than one of us has been engaged.

ARCYRIA FERRUGINEA Sauter. In my paper on the Long Island Mycetoza (*Mycologia* 28: 562. 1936), I described a phase of this species which I regarded as *Heterotrichia Gabriellae* Masee, and which I believed then might deserve species rank. Further collections have been made since that paper was written, so that I have now about a dozen, with some more that were determined by other students as *A. ferruginea*.

Dr. H. D. House, State Botanist at the New York State Museum in Albany, has kindly permitted me to examine the type from Copake of *Arcyria macrospora* Peck in the Herbarium there. The other type specimen from Ithaca is missing. This form, proposed by Peck (*Rep. N. Y. State Mus.* 34: 43. 1881), was examined by Sturgis (*Trans. Conn. Acad. Arts & Sci.* 10: 488. 1900) who regarded it as *A. ferruginea*. There is not much left of the type specimen, but it is unquestionably the same as the small phase, with large spores, that we have found so often. The collection of Peck is a perfect development. The type of *A. macrospora* from Ithaca was examined by Durand (*Bot. Gaz.* 19: 89. 1895), whose clear description indicates that it is the same as the Copake specimen.

Harvey (*Bull. Torrey Club* 24: 70. 1897) reported the collection of *Heterotrichia Gabriellae* Masee at E. Auburn, Maine, in

November, by E. D. Merrill who resided there at the time, and who recently was Director of The New York Botanical Garden. Harvey did not describe the form, but this was done afterwards by Macbride (N. A. Slime-Moulds 198. 1899) and carried through the later editions of his book. Dr. G. W. Martin has courteously sent to me for examination the portion of the Merrill collection that is in his custody, and on which Macbride based his description. Unfortunately, this description was not quite correct, and it has led to misunderstanding as to the true position of the form. The threads of the main capillitium are not double, that is, slender on the inside and broad on the outside. They are of fairly uniform breadth. There are many bulbous thickenings and many free ends, all indicative of an abnormal fruiting. The long basal threads connecting the capillitium with the cup are about one-half the breadth of the threads of the main capillitium, and occupy a cavity at the base when the capillitium lies in the cup. If such a capillitium is examined without drawing out the basal threads, it is easy to err and believe that they are part of the main mass. The spores are not $7-8\ \mu$ diam. The great majority measure $9.5-11\ \mu$ with many that are larger, up to $14\ \mu$; also a sign of imperfect development. In E. Auburn, Maine, the winter, or at least cold weather, sets in early, and the abnormal character of the fruiting is explained by the November period of collection. There is no doubt whatever that this form is the same as those mentioned before, only that it developed under adverse conditions.

All preceding forms are *Arcyria macrospora* Peck, the first published name, if they are regarded as distinct from *A. ferruginea*. They may be readily distinguished from the typical phase of the latter by their much smaller size; the densely aggregated habit; the long basal threads; the less elastic capillitium; and the larger spores, $10-12\ \mu$, which are usually smaller in the typical phase. Spore size here is about the only important differential character, there being no marked or constant capillitial differences. Macbride has always written the spore size of *A. ferruginea* as $10-12\ \mu$, and there is nothing in his description, nor in that of the Listers, to imply that *A. macrospora* is anything but a phase of *A. ferruginea*, and I may add, the much more common phase in eastern North America. Furthermore, the variations in our personally

collected specimens show approaches to typical *A. ferruginea* in several collections.

Massee's description of *Heterotrichia Gabriellae* (Mon. 140. 1892), from South Carolina, is similar to that of Macbride's description of the Maine form reported by Harvey. Massee mentions the irregularities of the capillitium and its double character, and gives the spore size as 7–8 μ diam. Lister (Mon. 185. 1894), after examination of the type specimen, states that the spore size is 10–11 μ , and regards it as *A. ferruginea*. He reports the numerous free ends, and the flattened, often thickened threads; but says nothing about the double character of the capillitium. Probably Massee erred in that as he did in the spore size, and mistook the narrower basal threads for the inner part of the capillitium. Torrend (Fl. Myx. 98. 1909) regarded Massee's form as a distinct variety of *A. ferruginea*. Grove (Birm. Nat. Hist. Phil. Soc. 12: 20. 1910) reported as *A. ferruginea* var. *Gabriellae*, certain British forms that were similar to Massee's. Dr. W. T. Elliott, of England, has kindly supplied me with such a specimen from Grove's collection, and found in late February, 1893. It is surely a cold weather development of the large, widely expanding, British phase of *A. ferruginea*. Many of the sporangia are hard and brittle; the capillitium has many free ends; and the spores are monstrously large, many as large as 30 μ diam. Lister (Mon. ed. 2, 234. 1911) accepted *A. Gabriellae* as *A. ferruginea* var. *Gabriellae*, following Torrend, and compared it to similar forms found repeatedly in the British Isles which have developed under unfavorable conditions. G. Lister (Mon. ed. 3, 230. 1925) followed similarly, and cited Grove's form together with Massee's as basic for the variety. The variety is now established in the literature with characters founded upon the abnormal characters of forms that are believed to have developed under adverse circumstances. Such a variety must be abandoned, but a solution should be proposed. From a careful study of the whole subject, I am firmly convinced that *Heterotrichia Gabriellae* Massee, from South Carolina, is the same as all the other American forms referred to in the earlier part of this paper, only abnormal, and that the name should be regarded as synonymous with *A. ferruginea*, as was done in the first edition of the Lister Monograph.

It is regrettable that so much confusion exists about these forms, and I have made an attempt to clear it by a study of all available material with the exception of Massee's type specimen which is in England. To sum up, the conclusions are that all forms mentioned herein, perfect or abnormal, with the exception of Grove's specimen, represent a small phase with large spores of *Arcyria ferruginea* Sauter, and that the phase is not rare in the eastern United States. Grove's specimen is eliminated as representing the larger, European phase. N. Y. B. G. Nos. 1136, 1350, 1463, 1608, 1610, 1614, 1658, 3064, 3067, 3371, 3372, 6912.

CRIBRARIA OREGANA Gilbert (Am. Jour. Bot. 19: 142. 1932). Dr. Gilbert has kindly furnished me with a portion of the type collection made in Oregon. A similar collection was made by my associate, Mr. Rispaud, in June of 1936, near High Point, in Sussex County, New Jersey, and a study and comparison of the two collections indicate that they are practically identical. Basing the opinion on all characters except the spores, the nearest neighbor to these forms is *Cribraria minutissima* Schw. In that species, forms with rib-less cups of varying sizes, and expanded nodes, do occur at times. The spores, usually, are remarkably regular in size and shape, and measure up to 7μ diam. In *C. oregana* the spores are considerably larger, and if the size and shape were fairly uniform throughout, there would be good reasons for confirming the validity of the species. Unfortunately this is not so. In the Oregon specimen about one-half of the sporangia examined have spores that in the main agree with Gilbert's measurement, $8-9.5\mu$, but in each sporangium there are spores that are 7μ or even less, in diameter. In the other half of the sporangia examined, the spore size is the same when globose, but many of the spores are irregular in shape, that is, ovoid, ellipsoid, or roughly angular. Exactly the same conditions prevail in the New Jersey development, and in addition, there are frequent monstrous spores up to 16μ or 18μ diam. Irregular spores usually indicate abnormal development. Unless later collections should appear with more regular spores, I must regard the present ones as abnormal developments of *C. minutissima*. N. Y. B. G. Nos. 3736, 7127.

Didymium Sturgisii nom. nov. Proposed in place of *Didymium anomalum* Sturgis, as the name applied by Sturgis was already preempted by Masee (Mon. 245. 1892).

Numerous plasmodiocarps of the species were found upon the bark of a dead aspen tree near Angels, Wayne County, Pennsylvania, in July, and permitted careful study of the characters, as they were in a perfect state of maturity. Similar, but smaller developments on the same tree in June, September, and October of the same year, and on other trees there and at High Point, in Sussex County, New Jersey, indicate that the species is not rare in that region, and may be looked for on the proper habitat throughout the season. The plasmodium of the July fruitings was large, and breaking up, emerged through small holes or pores made in the bark by insects. The plasmodiocarps in most instances surround the holes, but have formed away from them occasionally. They are small, 1–10 mm. across, rounded or irregular in shape with little branching or netting, but sometimes perforated or annular. Larger plasmodiocarps were formed by the confluence of portions of the plasmodium emerging from different holes. The plasmodiocarps are thin, 1–2 mm.; grayish white in color from the deposits of white, angular or stellate lime crystals on the yellowish, membranous wall; and rough, pitted or wrinkled on the surface. There is no columella nor capillitium unless the calcareous processes and their threads are regarded as capillitium. The spores are violet-brown by transmitted light; irregularly globose; minutely warted with some warts arranged in a few clusters on each spore; and measure 10–12 μ diam.

The calcareous processes between the base and upper wall consist of membranous tubes enclosing crystalline lime. They are firmly attached to one wall only, usually all of them to the upper one, but occasionally to the base or partly on each. When the plasmodiocarps are comparatively thick, the processes do not reach to the other wall and many of them are drawn to fine points or end in slender threads, and the other wall is almost smooth. In thinner plasmodiocarps they approach the opposite wall and meet there with short, calcareous protuberances, but are not firmly attached thereto. When mature and dry, the plasmodiocarps rupture along the edges, the upper walls curl up and separate completely from

the bases, and the unbroken attached processes and spores are exposed. The two walls may be easily separated with a needle. It is evident that if the walls were firmly united, there would be a serious obstacle to perfect dehiscence and spore dispersal. When the walls are separated, it will be seen that there are many short, slender, hyaline, threads attached to the processes, the protuberances, or the walls, and these are extensions of the membranous sheath surrounding the line of the processes. They constitute a true capillitium, undoubtedly connecting the two walls, although they cannot be observed in place because of their extremely slender nature and the thinness of the plasmodiocarps.

The prominent processes, which are characteristic of the species, lead to a first impression that it should be placed in a genus by itself. In other respects it is a *Didymium*, and in that genus we do have forms with parts of the capillitium thickened or expanded and filled with lime crystals. It will be seen from the foregoing that the true nature of the processes is similar. There is no sound reason for removing the species from the genus *Didymium*. N. Y. B. G. Nos. 3472, 3473, 3882, 3886, 3942, 3951.

FULIGO SEPTICA (L.) Weber. Noteworthy developments of an unusual phase of this abundant and well known species were found at Middleburg, in Schoharie County, New York, in late September. They were on the bark of cottonwood trees, that had been felled in the spring and placed in two stacks as cut timber to be used for firewood. The stacks were on opposite sides of a creek, flowing through a broad valley, but in open fields and exposed to the summer's sun. The developments consisted of hundreds of separated, pulvinate aethalia, ranging in size from 1-6 cm., with a few confluent and forming open or closed rings. The interesting feature in all is, that the usual cortex is replaced by a closely compacted, brain-like, layer of perfected sporangia, with capillitium and spores in each sporangium. The general color is a greenish white, with many of a dusky yellow or ochraceous tint, the last produced by brown refuse particles intermingled with the lime granules of the sporangial walls. The walls of the outer sporangia are pitted or mottled in appearance from scattered patches of lime granules on the membranous inner walls, when present, or from

attachments of the densely calcareous capillitia. The walls in many instances are clearly double; the inner, a thin, colorless, membrane, with the patches of lime mentioned; the outer, a compacted shell of white lime granules, widely separated from the inner one. In many aethalia, however, the inner walls cannot be discerned. The capillitium consists of short threads connecting large, white, branching lime-knots, which are united in a dense mass at the center, giving a *Badhamia*-like appearance. The spores are purple-brown by transmitted light and darker than usual in *F. septica*, distinctly warted, and mostly 9–12 μ diam. Some are smaller, a few larger, and they vary in different aethalia. The inner sporangia of the aethalia are similar to those in normal *F. septica*, twisted and anastomosing, with the peridial walls broken down. Several of the smaller aethalia with similar outside perfected sporangia, have thick, black stalks, in height about the size of the aethalia; others have membranous stalks, an elongation of the yellow hypothallus. These aethalia were on the under surfaces of the logs.

I am regarding these forms as closer to *F. septica* than to *Fuligo cinerea* (Schw.) Morg., although showing resemblance to the latter in the larger, darker spores, and the more robust capillitium. Similar forms are included in the Lister description of *F. septica*, and the note thereto, but are probably rarely met with, otherwise more attention would have been given to them by other authors. They may have developed under unusual conditions which are not clearly ascertainable by the ecological surroundings of the Middleburg wood stacks, and the same conditions may have affected the fruitings of *Stemonitis splendens* Rost., on the same wood and at the same time, and referred to later in this paper.

Associated with *F. septica*, also, were a dozen or more aethalia of *Mucilago spongiosa* (Leyss.) Morg. var. *solida*. These are compact, pulvinate or subglobose, measure from 2–6 cm. across, and resemble *F. septica* var. *candida* in superficial appearance. The cortex is firm and composed of rather large crystalline masses of white lime; the spores are darker than those of the *Fuligo* specimens, strongly marked with scattered spines which may be seen on the edges, and more regular in size, 10–11 μ . The scanty capillitium has no lime-knots. While crystalline lime may occur

occasionally in *F. septica*, the long, irregular, membranous processes which are present in some of the aethalia are characteristic of *M. spongiosa*. N. Y. B. G. Nos. 3674-3683, 3782-3788.

HEMITRICHIA ABIETINA (Wigand) Lister. A small gathering of this rarely collected species was made in Pike County, Pennsylvania, in October. The sporangia are small, about 0.5 mm., and on very short stalks that are filled with spore-like cells. The thin, membranous wall is evanescent above, persisting below as a rather deep calyculus. The netted capillitium has two or three left-handed spiral bands, sometimes varying within the same sporangium. The spores measure about 10μ diam. The collection is typical, agreeing with the Lister description and figures; and so is another that I have here, and which was collected by Prof. Thaxter, in Massachusetts, in 1885. Macbride & Martin restrict the spirals on the capillitium to one or two, and make no mention of stalked forms, although one is depicted in their figure. They also prefer the use of Persoon's *Trichia ovata* as the basic name for the species, following Macbride since 1899. The question as to which form Persoon intended to cover by that name is at least debatable. It is useless to waste time and argue over what somebody meant in the eighteenth century, unless it is clearly intelligible; and it is far better to adopt a later name with which all are in agreement that it represents the present form. Wigand's name does that and is here accepted. N. Y. B. G. No. 3911.

LYCOGALA CONICUM Pers. A collection of this rare species, consisting of between 40 and 50 aethalia, was made in September at the Cascades, near Mountain Lake, Virginia, in dense forest at an altitude of about 3,500 feet. The aethalia are small, about 1 mm. in size, subglobose with a tendency here and there to assume ellipsoid or conical shapes, and on broad bases. The color of the thin cortex is yellowish-brown, and covered with prominent, extended, branching or reticulated, brown, vesicles or thickenings. The form was associated on the same wood with *Lycogala exiguum* Morg., but the two in conjunction are readily separated. *L. exiguum* is larger in size, and the similarly colored peridium is thickly sprinkled with coarse, black warts between which are clusters of smaller thickenings, and which give a black appearance to the

whole. The same features are found in all collections of *L. exiguum* that we have made. The Listers regard the latter as a variety of *Lycogala epidendrum* (L.) Fries, but from a study of the two associated species, I am inclined to believe that it is more closely related to *L. conicum*. There are hardly any differences in the microscopic characters between the two smaller species. N. Y. B. G. Nos. 3696, 3699.

PERICHAENA MARGINATA Schw. Sussex County, New Jersey, and the Pocono Mountains in Pennsylvania, on the other side of the Delaware River, are regions in which *Perichaena corticalis* (Batsch) Rost. and its many phases may be found in abundance. In September, we collected in Wayne County, Pennsylvania, a perfect, typical, and fairly large fruiting of *P. marginata*. The walls of the sporangia are densely coated with small granules and flattened, lanceolate crystals of lime. Sometimes the coating is also on the inside of the wall, and extends to the hypothallus making that appear white. A hypothallus is often present in *P. corticalis*, and the presence of lime in it is of no more significance than it is in the wall. Otherwise there are no differences between the two forms.

P. corticalis, as well as *Perichaena depressa* Lib., is often found with lime crystals or granules in or on the walls in greater or lesser number. This should always be mentioned in descriptions of the two species. In *P. marginata* the lime is present in greater quantity, but this is hardly a good reason for maintaining it as a distinct species. A variable character such as the amount of lime or refuse matter in the wall should not be considered as of specific importance. *P. marginata* is merely a phase of *P. corticalis*, and no more a species than similar phases in *P. depressa* or *Trichia contorta* (Ditmar) Rost. Furthermore, our collection has several groups of limeless sporangia—normal *P. corticalis*—among those that are coated with lime. N. Y. B. G. No. 3877.

PERICHAENA QUADRATA Macbr. This is no more than one of the phases of *Perichaena depressa* Lib. It may be found in almost any large, wide spreading fruiting of *P. depressa*, when the plasmodium breaks up and produces numerous small developments with few that are alike. We have one large fruiting of this kind

from Long Island, New York, which has many colonies of several phases from the large, flattened, typical, sporangia with lids, to the small, crowded, polygonal phase of *P. quadrata*. The sporangia of the latter are convex or flattened, and sometimes separated, but retaining the polygonal shape. Some of the colonies have as many as a hundred or more of the smaller sporangia. We have other similar collections, and also fruitings where the phase is not associated with other phases. The fact that colonies with uniform sporangia throughout are often found is of little significance, as *P. depressa* usually forms small developments of uniform sporangia, but many colonies differ in size, shape, or color of the sporangia, or in the presence or absence of lime. Slight differences in microscopic characters are also of no importance, as they occur in any fruiting with different phases. *P. quadrata* is not a species, and should be regarded as synonymous with *P. depressa*.

Forms that approach various phases of *P. depressa* are occasionally found in large fruitings of *Perichaena corticalis* (Batsch) Rost., when, of course, their affinity is seen. When separated, however, the relationship is often uncertain, although a careful study of spore and capillitial characters may establish it. They, and some of the rounded phases of *P. depressa*, are intermediate between typical forms of the two species, approaching either, as the case may be. Many specimens in the Herbarium of The New York Botanical Garden.

PHYSARUM OBLATUM Macbr. The species deserves attention, as its position and relations to other species are so confusing that the student finds it difficult to understand them. It was proposed by Macbride in 1893. In the first edition of the North American Slime-Moulds, he changed his opinion and regarded it as a phase of *Physarum auriscalpium* Cooke, at the same time treating *Crateurium Maydis*, proposed by Morgan in 1896, as a separate species. This last form was removed later by Torrend to the genus *Physarum* where it belongs. In the second edition of his book, Macbride reestablished *P. oblatum* as a species, and placed *Physarum Maydis* (Morg.) Torr. as synonymous therewith. The same position was retained by Macbride & Martin in the Myxomycetes, 1934. The Listers have consistently regarded *P. oblatum* as a phase of *P.*

auriscalpium, although in the last edition of the Monograph, the former is cited as partially synonymous with *P. Maydis*, which is regarded as a species.

Macbride's form is common on dead wood throughout the mountainous regions of the eastern United States, and we have collected it on many occasions. Morgan's form on herbaceous stalks has also been collected, and aside from the different habitat, and that it is not as robust as the other, there is nothing to distinguish the two. The forms, in my opinion, are the same and Macbride's name has priority. If one is regarded as a phase of *P. auriscalpium* the other should also be, and while there are circumstances that seem to indicate this for both, I am not convinced enough to support such a theory at the present time.

All of the forms mentioned are often alike in all characters but the length of the stalks. They vary considerably in the color of the lime, inside and outside of the sporangia, which may be yellow, orange, or orange and white, or white throughout. *P. oblatum* usually has long stalks, often twice or more the diameter of the sporangia, but may have shorter ones. *P. auriscalpium* is usually sessile, but frequently has stalks as long as the diameter of the sporangia. They both form small colonies of sporangia, less than an inch across, but usually several or many are found on one dead tree or other habitat, with wide variation among them. When such a series is found with sessile sporangia and some stalked ones, it is regarded here as *P. auriscalpium*. When the sporangia are all stalked, with stalks of different lengths, it is regarded as *P. oblatum*. We have collected several such series representing each species, and when I take a portion of one species with stalks of a certain length, and compare it with a portion of the other with stalks of the same size, the determination of each species is pure guess-work. The fact is that *P. auriscalpium* and *P. oblatum* are practically alike in certain phases, and are then indistinguishable unless the field conditions are known.

P. auriscalpium at times forms short plasmodiocarps or *Badhamia*-like capillitial lime. When these are combined, and the color is yellow, it is difficult to distinguish the form from *Badhamia decipiens* (Curtis) Berk. When the color is white throughout, and the lime is heavy, it may be confused with certain white forms

of *Badhamia*. *P. auriscalpium* is also said to approach *Physarum rubiginosum* Fries, but our collections of the latter are generally typical, and the form is not common in our territory. Many specimens in the Herbarium of The New York Botanical Garden.

PHYSARUM OVISPORUM G. Lister. On various occasions during the summer of 1936, we have found in all about 7 or 8 developments of a certain *Physarum*, in a small kettle hole in the foothills of the terminal moraine about two miles north of Mineola, Long Island, New York. All the fruitings were on twigs, small sticks, or leaves, and are identical. They consist of scattered, white, sessile, pulvinate, or subglobose sporangia, 0.15–0.5 mm. diam., or short, elongated plasmodiocarps. At the bases the sporangia are generally contracted, and the walls there are dark or iridescent and free from lime. Above, the wall is covered with deposits of white lime granules, thickened in patches, and with smoother areas, or areas almost free from lime between the patches. The capillitium consists of large, angular, branching, lime-knots, enclosing lime granules about $1\ \mu$ diam., and connected by hyaline threads without lime, which are about the length of the lime-knots. The capillitium in many instances appears almost *Badhamia*-like. The spores are both globose and ovoid in every sporangium, the ovoid spores predominating, and measure about $9.5\ \mu$ for the globose ones, and $9 \times 11\ \mu$ to $10 \times 12\ \mu$ for the ovoid ones. The color is purple-brown; they are minutely warted; and a pale, smooth, sinuous dehiscence line is visible on some of the spores.

These forms agree with the description and figures of *P. ovisporum*, except in the small size of the sporangia, and the angular, branching lime-knots, which are rounded in the typical form. The diversity in size among the sporangia is a noticeable feature, and, with the rough walls, they do not look like the usually smooth, evenly sized sporangia of *Badhamia ovispora* Racib. The rather long threads connecting the lime-knots place them in the genus *Physarum*, and as in many species of that genus the lime-knots may be either rounded or angular, the differences are not sufficient to regard our collections as other than *P. ovisporum*. The species has a limited geographical range, so far as known, and has not been reported from North America heretofore, so that phases

here are not understood. Later collections may indicate a closer resemblance to the typical European form. N. Y. B. G. Nos. 1892, 1893, 1897.

STEMONITIS SPLENDENS Rost. Many developments of the varieties *Webberi* and *flaccida* of this species were found upon the logs of the same wood piles described under *Fuligo septica*. Probably a hundred in all, ranging from 1–4 cm. in size, with a few larger. In some of them the collumellae are straight and stiff; in others weak, twisted, or bent, so that the sporangia are inclined. The capillitia are poorly developed, often without a surface net, again with a coarse net of wide meshes. Sometimes the surface net consists of smaller meshes and approaches the net of typical *S. splendens*, but typical forms with perfect capillitia appear to be absent. The variations occur often in the same cluster. The spores are the same as those of normal *S. splendens*.

The forms have been regarded as two distinct species, *Stemonitis Webberi* Rex, and *Comatricha flaccida* (Lister) Morg. One is enough, and that should be *S. Webberi*, if there are reasons for doing so, as the merging of the forms shown in our collections has also been noted by others. However, the forms are clearly erratic or poorly developed phases of *S. splendens*, and collections of the latter often show an intermediate position between them and so-called *S. Webberi*. The association of our specimens with unusual phases of *Fuligo septica* would indicate that unknown factors were present to influence both species during the period of the activity of the plasmodia, or at the time of fructification. N. Y. B. G. Nos. 3670–3673.

TRICHIA CASCADENSIS Gilbert (Am. Jour. Bot. 19: 145. 1932). The species is based upon a collection from Oregon. We have a small, perfectly matured collection made at Tarratine, Somerset County, Maine, in August, which consists of large, scattered, sessile sporangia and elongated plasmodiocarps ranging from 1–2 mm. in size. The wall is single, dark purple on both sides—appearing almost black—and charged with dark granular matter. The elaters of the capillitium are regularly and evenly wound like a left-handed screw with spirals 7–8 μ in breadth, and winding to the ends which are rounded, with occasionally a short acuminate-

rostrate point. The small warts are present along the spirals, although not as prominently as Gilbert figures, and the longitudinal lines showing the core are clearly evident. The spores, by transmitted light, are pale yellow, irregularly globose to ovoid, minutely spinulose, and measure 14–17 μ diam.

This form is dangerously close to *Trichia alpina* (R. E. Fries) Meylan notwithstanding the absence of the inner wall. I have often found in collections of erratic phases of certain species, that the inner wall is indistinguishable or missing, although known to be present in typical examples. The capillitial differences are of little significance by themselves, as one or more of them are often present in phases of *Trichia contorta* (Ditmar) Rost. or its varieties, a species allied to *T. alpina* and also to the present form. *T. contorta* is a very variable species, and its numerous variations, named and not named, are found abundantly in the eastern United States. A wide experience in their collection has taught me to place little reliance upon the constancy of the many phases. If the combination of characters assigned to *T. cascadiensis* should be found constant in further collections—and the Maine gathering partly confirms this—the species may be well established; otherwise it should be regarded as an erratic phase of *T. alpina* or *T. contorta*, in my opinion closer to *T. alpina*. N. Y. B. G. No. 3495.

TRICHIA CONTORTA (Ditmar) Rost. The species is abundant throughout the states in which we have been, in fact one of the common forms. It is very variable, producing phases some of which are regarded as varieties or even as distinct species. A close study of many collections, among which we have specimens that overlap in the characters ascribed to these varieties or species, convinces me that they are not species, and that the matter of retaining them as varieties is questionable. If the practice of recognizing more and more varieties is continued, it will not be long before we will be in the position that we were in before the days of Rostafinski, when everything that looked different was a species; only later, everything will be a variety. It would be better to broaden the descriptions of many species so as to include all or most of the phases, just as has been done with others, notably *Didymium squamulosum* (Alb. & Schw.) Fries.

The typical phase of *T. contorta* has capillitial elaters that are uneven, and on which the spirals are irregularly wound or often faint. We have collected a curious form at Mountain Lake, Virginia, at an altitude of 4,100 feet, which has no capillitium. In place thereof are a number of dark, spore-like bodies, some of which have short extensions or processes, as many as three, with faint spirals. One very short, free, elater was observed.

Var. *inconspicua*, or *Trichia inconspicua* Rost. as it is also regarded, has even elaters and the spirals wind regularly. However, there are all sorts of intermediate degrees between it and the typical phase, and sometimes they are in the same colony. The elater terminals are also variable, but not confined or constant to one phase. The differences are no more than varietal—if they are that—and are not sufficient to regard it as a distinct species. The phase is more often collected in the eastern states than all other phases of *T. contorta* combined, and undoubtedly represents the highest development of the species.

Var. *iovensis*, or *Trichia iovensis* Macbr., has long spines on the elaters. Macbride described it as having spiral bands unevenly distributed, which means as in the typical form. The Listers, who regard the phase as var. *iovensis*, say the elaters are as in var. *inconspicua*, which means regularly wound. We have collected a form in Maine that fits Macbride's description with irregular spirals; others from New Hampshire and New Jersey have regular spirals as the Listers say; and a fourth from Maine has gray sporangia, densely coated with lime deposits, and the elaters of var. *inconspicua*. All in one season and with long spines on the elaters. Lime covered forms have been reported before, and occur often in two species of *Perichaena*. They are not regarded as of specific importance in *T. contorta*, and should not be in *Perichaena*. Spines on three of the phases of *T. contorta* show that they are not even of varietal value, and that the description should be altered to cover them, with the elimination of *iovensis* as a species or variety name. Many specimens in the Herbarium of The New York Botanical Garden.

OBSERVATIONS ON THE COMPARATIVE MORPHOLOGY AND TAXONOMIC RE- LATIONSHIPS OF CERTAIN GRASS SMUTS IN WESTERN NORTH AMERICA ¹

GEORGE W. FISCHER ²

(WITH 18 FIGURES)

Smut diseases of various species of barley grasses (*Hordeum* spp.), brome grasses (*Bromus* spp.), and wheat grasses (*Agropyron* spp.) are common in the northwestern United States and in western Canada. Inasmuch as these grasses are of importance for range and forage purposes, severe smut infestations undoubtedly account for significant losses, both in feed value and seed production. Therefore, from an economic point of view, a thorough knowledge of the fundamental nature of the organisms which cause these smuts is highly desirable. Unfortunately very little of this type of information is available. As a preliminary to extensive investigations on this subject detailed observations regarding certain taxonomic phases of the grass smut fungi have been made and are herein reported.

SMUT OF BARLEY GRASSES, HORDEUM SPP.

Ustilago Lorentziana Thüm. is the smut most commonly found on barley grasses in the Northwest, especially on *Hordeum nodosum* L. and *H. jubatum* L. Clinton (3) lists *H. caespitosum* Scribn., *H. jubatum*, *H. maritimum* With. (*H. marinum* Huds.), *H. murinum* L., *H. nodosum*, and *H. pusillum* Nutt. as hosts to

¹ Grass disease investigations of the Division of Forage Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, in cooperation with the Soil Conservation Service, Section of Nurseries, and the Divisions of Plant Pathology and Agronomy of the Washington State College Agricultural Experiment Station.

² Associate Pathologist, Division of Forage Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture.

this smut in the United States. Lefebvre and Johnston (8) recently reported *H. gussoneanum* Parl. as a host. The following description of *U. lorentziana* is taken from Clinton (3):

Sori in spikelets, usually infecting all of a spike, rather completely destroying their parts except the awns, protected at first by a thin transparent membrane which easily ruptures disclosing a dusty purple-black spore-mass; spores rather dark olive-brown, ovoid to spherical or sometimes with more irregular and angular forms, with a brittle epispore that breaks up into more or less irregular granules or minute verruculations, chiefly 7-12 μ in length.

The writer's collections do not differ essentially from this description. Figure 3 shows the typical appearance of the smut on *Hordeum nodosum*. A photomicrograph of the spores may be found in figure 14.

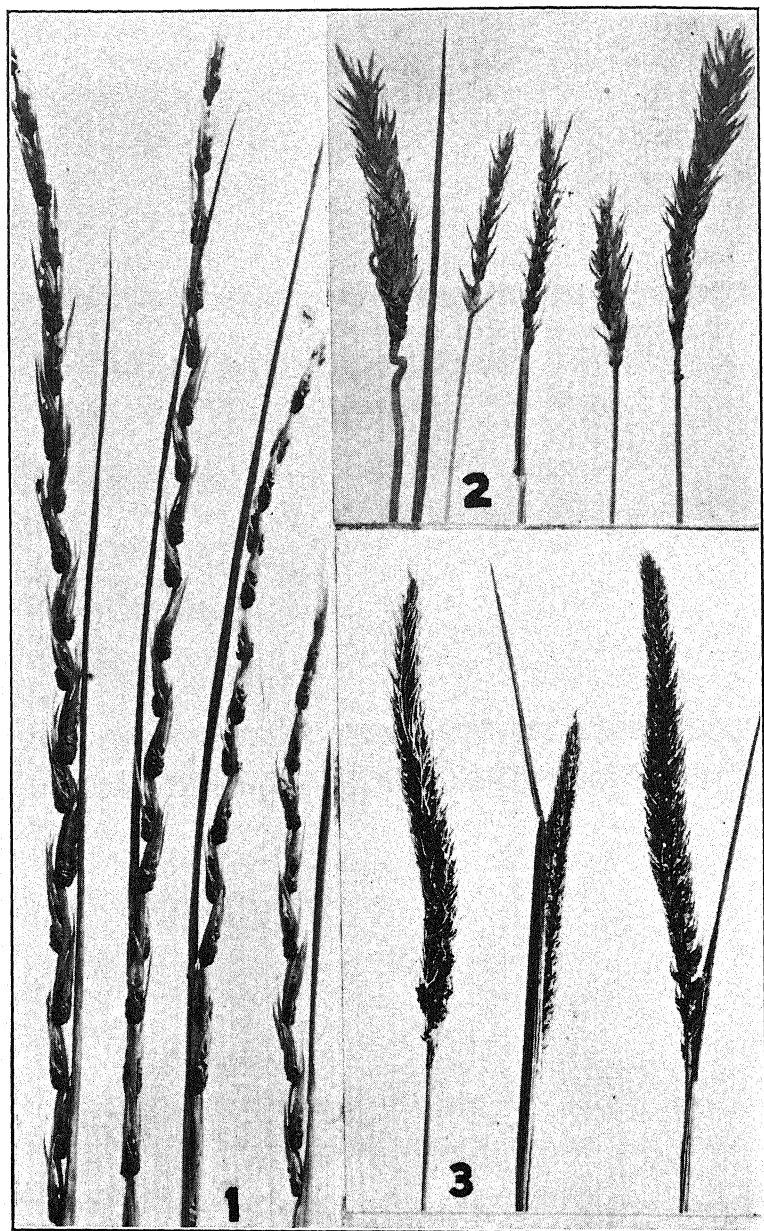
It is not intended to present here the results of inoculation experiments with these smut fungi, this being reserved for a later paper, yet it should be pointed out that inoculation experiments with other grasses have shown the susceptibility of *Elymus striatus* Willd. to *Ustilago Lorentziana*. It cannot be said, therefore, that this smut is confined to the genus *Hordeum*.

SMUT OF BROME GRASSES, *BROMUS* SPP.

A very common smut on brome grasses has been described as *Ustilago bromivora* (Tul.) Fisch. von Waldh. Clinton (3) lists the following species of *Bromus* as hosts in the U. S.: *Bromus arvensis* L., *B. breviaristatus* Buckl., *B. ciliatus* L., *B. Hookerianus* Thurb. (*B. carinatus* Hook. and Arn.), *B. hordeaceus* L. (*B. mollis* L.), *B. hordeaceus glabrescens* Shear (*B. racemosus* L.), *B. Kalmii* A. Gray, *B. marginatus* Nees., *B. polyanthus* Scribn., *B. pumpellianus* Scribn., *B. racemosus* L., *B. Richardsoni* Link. (*B. ciliatus*), *B. secalinus* L., *B. vulgaris* (Hook.) Shear, *B. vulgaris eximius* Shear. Garret (7) in 1921, and Zundel (16) in 1921 added *B. tectorum* L. to the list, the latter writer stating that the smut on this host was occurring in epiphytotic form in Box Elder County, Utah.

Clinton (3) describes *Ustilago bromivora* as follows:

Sori in spikelets, usually infecting only the parts within the glumes but sometimes also destroying the base of these, often at first agglutinated but finally becoming dusty; spores usually dark reddish-brown, chiefly ovoid to



FIGS. 1-3. 1, Characteristic appearance of *Ustilago bullata* on slender wheat grass, *Agropyron pauciflorum*; 2, *ibid.*, on crested wheat grass *A. cristatum*; 3, *Ustilago Lorentziana* on *Hordeum nodosum*. Nat. size.

spherical but occasionally polyhedral or irregular, sometimes apparently smooth or only granular, but usually abundantly and minutely granular-verruculose, 7-11 μ , rarely 14 μ , in length.

A smut, with larger ("11-17 μ "), more irregular spores, is listed on *Bromus ciliatus* by Clinton (3) and on *B. tectorum* by Zundel (15), under the name *Ustilago bromivora* var. *macrospora* Farl. Concerning this variety, Pammel *et al.* (13) state that "the *Ustilago bromivora*, Fisch. de Wald. is apparently the variety *macrospora* of Farlow."

In the Pacific Northwest *Ustilago bromivora* occurs most abundantly on *Bromus tectorum*, and areas are common in which this grass is 90-95 per cent infected. The smut is less common, although by no means rare, on *B. marginatus*, *B. polyanthus*, and *B. mollis*.

During the past two years the writer has made extensive collections of *Ustilago bromivora* and has had several collections sent to him. These collections established several species of *Bromus* as apparently heretofore unreported hosts in the U. S. The data concerning these are presented in Table 1.

SMUT OF WHEAT GRASSES, AGROPYRON SPP.

The predominant smut on *Agropyron* in the Northwest and especially on slender wheat grass, *A. pauciflorum* (Schwein.) Hitchc., is one that has received attention in Canada under the name of *Ustilago bromivora* by Padwick and Henry (12) and Fraser and Scott (6). In general appearance the affected spikes are very similar to barley spikes affected with *U. Hordei* (Pers.) K. and S. (FIG. 1). The spores are scarcely distinguishable from those of *Ustilago bromivora*, which fact led Fraser and Scott (6) to assign the smut to this species. Their description of this smut on "western rye grass" (slender wheat grass) follows:

The smut attacks the spikelets, destroying the ovaries and usually the bases of the glumes, although frequently the outer glumes are not affected. The sori are large, irregular, rather firm at first, but finally dusty. The spore mass is dark brown to black in color. Usually all the spikelets are affected, but sometimes only the upper ones are smutted. The spores are usually spherical, sometimes oval, dark brown, finely verrucose, and mostly 8-11 μ in diameter, averaging 9.2 μ . The spores germinate readily in 5 per cent sugar solution and less freely in water. Sporidia are produced in sugar solution in a few hours.

TABLE 1
SPECIES OF *Bromus* NOT PREVIOUSLY REPORTED AS HOSTS FOR *Ustilago bromivora*

| Species | Collector | Locality and Date | Remarks |
|-------------------------------------|--------------------------------------|----------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|
| <i>B. arduensis</i> Dum. | G. W. Fischer | Pullman, Wash. July, 1936 | Resulting from inoculation with smut from <i>B. mar-</i> <i>ginatus</i> |
| <i>B. brachystachyus</i> Hornung .. | G. W. Fischer | Pullman, Wash., Aug., 1936 | Resulting from inoculation from <i>B. mollis</i> |
| <i>B. brizaeformis</i> F. & M. | 1. G. W. Fischer 2. Unknown | Palouse, Wash., Aug., 1935 Southwestern Idaho Aug., 1935 | |
| <i>B. catharticus</i> Vahl. | 1. R. Sprague 2. C. O. Johnston | Astoria, Ore., Aug., 1936 College Station, Texas | |
| <i>B. erectus</i> Huds. | G. W. Fischer | Pullman, Wash. Aug., 1936 | Collected in the Soil Conservation Nurseries; the grass had originally been obtained from South- western Idaho |
| <i>B. japonicus</i> Thunb. | C. O. Johnston and C. L. Lefebvre | Manhattan, Kans. July, 1935 | |
| <i>B. squarrosus</i> L. | G. W. Fischer | Pullman, Wash. Aug., 1936 | Collected in Soil Conservation Nurseries; the grass had originally been obtained from Ukraine, U.S.S.R. |
| <i>B. sterilis</i> L. | G. W. Fischer | Pullman, Wash. | |

Mourashkinsky, in Russia (11), reported a smut of "American rye grass" (slender wheat grass) having symptoms and morphology identical with those of the smut of this host as described by Fraser and Scott (6) in Canada, and considered it to be the same disease. However, considering that Liro (9) had shown that certain races of *Ustilago bromivora* are very closely specialized to a few *Bromus* spp., Mourashkinsky believed that the smut on *Agropyron* could better be assigned to *U. bullata* Berk.

U. bullata was originally described on *Agropyron scabrum* Beauv. from New Zealand by Berkeley (1) in 1855, but the following description is taken from McAlpine (10):

Sori produced in the inflorescence and destroying it, at first enclosed in a greyish or leaden-coloured membrane which is soon ruptured, exposing the dark-brown to black compact mass of spores, sometimes only attacking a portion of the spikelets. Spores globose to subglobose or ellipsoid, olive-brown, densely warted, 8-11 μ in diam. or 10-12 \times 7-8 μ , occasionally reaching a length of 14 μ .

A specimen on *Agropyron scabrum* collected and determined in November, 1934 by C. C. Brittlebank in Australia as *U. bullata*, has been received from Dr. George Zundel, Pennsylvania State College. An examination of this material, especially microscopically, showed that it was indistinguishable from the smut so common in the Pacific Northwest and Western Canada on *Agropyron pauciflorum*. Considering this, the latter smut could well be assigned to *Ustilago bullata*.

Fraser and Scott (6) found that *Agropyron dasystachyum* (Hook.) Scribn. and *A. Richardsoni* Schrad. (*A. subsecundum* (Link) Hitchc.) were also susceptible to this smut of slender wheat grass. Recently, Padwick and Henry (12) added *A. Griffithsii* Scribn. and Smith to the list.

Fraser and Scott (6) reported the infection of *Bromus ciliatus* and *B. latiglumis* (Shear) Hitchc. with spores from slender wheat grass. However, since the percentage of infection was quite low, and since they neither used treated seed nor check rows in the experiment, these results are, as these authors point out, inconclusive.

In this connection, the writer has made several attempts to infect *Agropyron* spp. with smut from *Bromus* spp. and *vice versa*, using either treated seed or check rows, or both, and has not yet suc-

ceeded in obtaining infection in either instance. Such results indicate, but do not establish, the specialization of brome grass smut to brome grasses and wheat grass smut to wheat grasses.

A smutted plant of crested wheat grass was found in the grass smut nursery at Pullman, Wash., in July, 1935. The smut partially destroyed the spikelets, and its general symptoms, as well as the morphology of the spores, were notably similar to the common smut (*Ustilago bullata*) of slender wheat grass. Several samples of "smutty" crested wheat grass seed were received from the Adam's Branch Experiment Station, Lind, Washington, in September of the same year. Most of the samples contained bunt in varying percentages (due to *Tilletia Tritici* (Bjerk.) Wint.), but several of the samples contained fragments of a smut which obviously was the same as the one previously collected on crested wheat grass at Pullman. The nursery at Lind was inspected in June, 1936, and several specimens of the same smut were found, and in July a considerable amount of it was collected in the Soil Conservation Nurseries, at Pullman. The morphology of the spores is given in Table 2 (collection N-B, of *Ustilago bullata*). The appearance of the smutted spikes is shown in figure 2 and the general morphology of the spores is illustrated in figure 12.

TABLE 2

VARIATION IN THE EPISPORE IN 20 COLLECTIONS OF *Ustilago bullata*, *U. bromivora*, *U. bromivora macrospora*, AND *U. Lorentziana*

| Species | Collection Symbol | Host | Character of Epispore |
|-------------------------------|-------------------|-------------------------------|--------------------------------------|
| <i>U. bromivora</i> | M-A | <i>Bromus tectorum</i> | Bluntly echinulate—verrucose |
| <i>U. bromivora</i> | M-B | <i>Bromus mollis</i> | Bluntly echinulate—verrucose |
| <i>U. bromivora</i> | M-C | <i>Bromus marginatus</i> | Rather coarsely echinulate—verrucose |
| <i>U. bromivora</i> | M-F | <i>Bromus japonicus</i> | Minutely echinulate—verrucose |
| <i>U. bromivora</i> | M-G | <i>Bromus erectus</i> | Bluntly echinulate—verrucose |
| <i>U. bromivora</i> | M-H | <i>Bromus</i> sp. | Minutely verrucose |
| <i>U. bromivora</i> | M-I | <i>Bromus catharticus</i> | Rather minutely verrucose |
| <i>U. bromivora</i> | M-J | <i>Bromus squarrosus</i> | Minutely verrucose |
| <i>U. bromivora</i> | M-K | <i>Bromus</i> sp. | Very minutely echinulate—verrucose |
| <i>U. bromivora</i> | M-L | <i>Bromus</i> sp. | Coarsely verrucose |
| <i>U. bromivora</i> | M-N | <i>Bromus sterilis</i> | Rather coarsely echinulate—verrucose |
| <i>U. bromivora</i> | M-O | <i>Bromus brizaeformis</i> | Rather finely echinulate—verrucose |
| <i>U. br. macrospora</i> . . | | <i>Bromus ciliatus</i> | Finely verrucose |
| <i>U. bullata</i> | N-A | <i>Agropyron pauciflorum</i> | Rather finely echinulate—verrucose |
| <i>U. bullata</i> | N-B | <i>Agropyron cristatum</i> | Minutely verrucose |
| <i>U. bullata</i> | N-C | <i>Agropyron dasystachyum</i> | Finely echinulate—verrucose |
| <i>U. bullata</i> | N-D | <i>Agropyron scabrum</i> | Finely echinulate—verrucose |
| <i>U. Lorentziana</i> | R-A | <i>Hordeum nodosum</i> | Echinulate—verrucose |
| <i>U. Lorentziana</i> | R-B | <i>Hordeum jubatum</i> | Finely echinulate—verrucose |
| <i>U. Lorentziana</i> | R-E | <i>Hordeum gussoneanum</i> | Finely echinulate—verrucose |

Apparently this is the first report of such a smut on crested wheat grass. Its gross morphology is the same as that of the smut which occurs on slender wheat grass. However, Padwick and Henry (12) were unable to infect crested wheat grass with smut from slender wheat grass. This may be due to their not having used susceptible strains of crested wheat grass. In this connection it should be pointed out, perhaps, that most of the writer's collections of this smut on crested wheat grass have been on the variety "Fairway."

The striking similarity in gross morphology of the smuts caused by *Ustilago bromivora*, *U. bullata*, and *U. Lorentziana* suggested the desirability of studying the comparative morphology of the spores in different collections of these species.

COMPARATIVE MORPHOLOGY OF *USTILAGO BROMIVORA*, *U. BULLATA*, AND *U. LORENTZIANA* SPORES

An analysis has been made of 19 collections of smut, including 12 of *Ustilago bromivora* from at least 10 species of *Bromus*, 4 of *U. bullata* from the same number of species of *Agropyron*, and 3 of *U. Lorentziana* from 3 species of *Hordeum*, to determine the comparative morphology of the chlamydospores of these smut species. Measurements (diameter only) were made of 100 spores, selected at random, of each collection, to determine the variations and range in spore size. A study was also made of the character of the epispore in each collection. These 19 collections were selected for these studies because they are also being investigated with regard to life history, host range, and cultural characters on artificial media. A sample of the type collection of *U. bromivora* var. *macrospora* (discussed below) was included for comparative purposes. The data showing the collection symbol, host, and character of the epispore are presented in Table 2. The data concerned with spore size are presented in Table 3.

In Tables 2 and 3 it is seen that, at least insofar as these 19 collections which were studied are concerned, there is much more variation within *Ustilago bromivora*, as a species, than exists between *U. bromivora* and either *U. bullata* or *U. Lorentziana*. Thus it is seen that collection M-K of *U. bromivora* has characteristically small spores, with the mode at 6 μ , and an average at

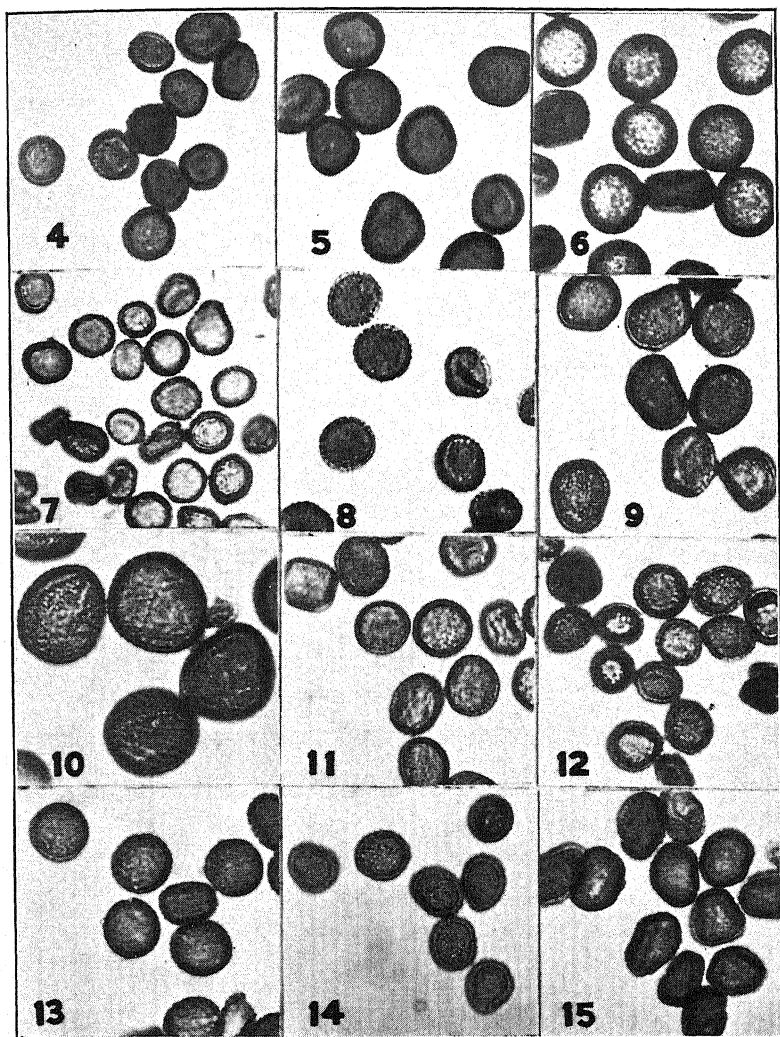
TABLE 3

FREQUENCIES OF THE DIAMETERS OF THE SMUT SPORES OF 20 COLLECTIONS OF *Ustilago bullata*, *U. bromivora*, *U. bromivora macrospora*, AND *U. Lorentziana*

| Collection Symbol | Classes | | | | | | | | | | Mean Diameter μ |
|---------------------|---------|---------|---------|---------|---------|----------|----------|----------|----------|----------|------------------------|
| | 5 μ | 6 μ | 7 μ | 8 μ | 9 μ | 10 μ | 11 μ | 12 μ | 13 μ | 14 μ | |
| M-A | | 28 | 46 | 26 | | | | | | | 6.98 |
| M-B | | 2 | 6 | 36 | 39 | 16 | 1 | | | | 8.64 |
| M-C | | 1 | 8 | 43 | 44 | 4 | | | | | 8.42 |
| M-F | | | 2 | 12 | 45 | 40 | 1 | | | | 9.26 |
| M-G | | 11 | 29 | 59 | 1 | | | | | | 7.50 |
| M-H | | | 1 | 5 | 44 | 48 | 2 | | | | 9.05 |
| M-I | | | 3 | 38 | 53 | 6 | | | | | 8.62 |
| M-J | | | | 1 | 23 | 54 | 20 | 1 | 1 | | 10.00 |
| M-K | 23 | 63 | 12 | 2 | | | | | | | 6.03 |
| M-L | | 1 | 19 | 47 | 30 | 3 | | | | | 8.15 |
| M-N | 1 | 29 | 44 | 25 | 1 | | | | | | 6.96 |
| M-O | | | | 16 | 61 | 22 | 1 | | | | 9.08 |
| <i>U. bromivora</i> | | | | | | | | | | | |
| <i>macrospora</i> | | | | 1 | 4 | 15 | 40 | 21 | 14 | 5 | 11.38 |
| N-A | | 6 | 14 | 59 | 21 | | | | | | 7.95 |
| N-B | | 22 | 52 | 26 | | | | | | | 7.04 |
| N-C | 1 | 35 | 39 | 23 | 2 | | | | | | 6.90 |
| N-D | | 17 | 43 | 37 | 3 | | | | | | 7.26 |
| R-A | | 6 | 30 | 57 | 7 | | | | | | 7.65 |
| R-B | | 2 | 16 | 60 | 22 | | | | | | 8.02 |
| R-E | | 8 | 33 | 41 | 15 | 3 | | | | | 7.72 |

6.03, in diameter, and that collection M-J of the same species has characteristically large spores, with the mode and mean both at 10 μ . Similarly, collection M-K is distinct for the character of the epispore which is very minutely echinulate-verrucose, almost smooth. Collection M-L, on the other hand, is just as distinct for its rather coarsely verrucose spores. Further examination of Tables 2 and 3 show that all intergradations between the extremes just mentioned are to be found in the remaining 9 collections of *U. bromivora*. Ciferri (2), has also found differences in the modes for spore diameter in collections of *U. bromivora*, as, for example, 7 μ on *Bromus maximus* Desf. and 9 μ on *B. fasciculatus* Presl.

Much less variation is seen in the collections of *U. bullata* and *U. Lorentziana*. Of the former species, collection N-C (on *Agropyron dasystachyum*) had the smallest spores, with a mean diameter of 6.90 μ , which is only approximately 1 μ less than those of collection N-A (on *A. pauciflorum*). In *U. Lorentziana* the



FIGS. 4-15. 4, *Ustilago bromivora* (collection M-A) spores from *Bromus tectorum*; 5, *ibid.* (collection M-B), from *B. mollis*; 6, *ibid.* (M-J), from *B. squarrosus*; 7, *ibid.* (M-K), from *Bromus* sp.; 8, *ibid.* (M-L), from *Bromus* sp.; 9, *ibid.* (M-O), from *B. brizaeformis*; 10, *Ustilago bromivora* var. *macrospora* Farl., spores from type material supplied by Dr. G. P. Clinton; 11, *U. bullata* (collection N-A) from *Agropyron pauciflorum*; 12, *ibid.* (N-B), from *A. cristatum*; 13, *ibid.* (N-D), from *A. scabrum*, received from Australia through Dr. G. L. Zundel; 14, *U. Lorentziana* (R-A), from *Hordeum nodosum*; 15, *ibid.* (R-E), from *H. gussoneanum*. All $\times 1000$ and all photographed with same set-up of camera, microscope, illumination, and magnification.

only characteristic collection was R-E (from *Hordeum gusoneanum*) in which the spores were less regular, ranging from 6–10 μ . However, the mean diameter of 7.72 μ is essentially equal to that of the other two collections. It is further seen that, on the basis of the collections analyzed, *U. bullata* and *U. Lorentziana* are scarcely distinct morphologically.

These differences and similarities in the 19 collections of *U. bromivora*, *U. bullata*, and *U. Lorentziana* (also one specimen of *U. bromivora macrospora*) are illustrated to some extent in figures 4–15.

The foregoing data might indicate that collections of a smut species on different hosts might be expected to show morphological differences. The question arises as to whether various collections of smut species on the same host species would also show such differences. With this in mind, examinations have been made of 41 herbarium³ specimens of *U. bromivora*, 10 of *U. Lorentziana*, and 3 of *U. bullata*.⁴ Twenty-six of the 41 specimens of *U. bromivora* were on *Bromus tectorum*, 5 on *B. mollis*, 6 on *B. carinatus* (including *B. marginatus* and *B. polyanthus*), and 2 each on *B. commutatus* and *B. secalinus*.

In most of the specimens on *B. tectorum* the mean spore diameter ranged from 7 to 8.18 μ in diameter. A few of the specimens contained larger spores, averaging 8.56 to 9.15 μ in diameter. The epispore varied from minutely echinulate-verrucose to verrucose.

On *Bromus mollis*, the collections revealed much less variation, all having spores which averaged 9.1–10.23 μ in diameter, and all being echinulate-verrucose or minutely so. The same was true for the collections on *B. carinatus*, in which case the averages ranged from 8.76–9.64 μ , and the spores were either echinulate-verrucose or verrucose.

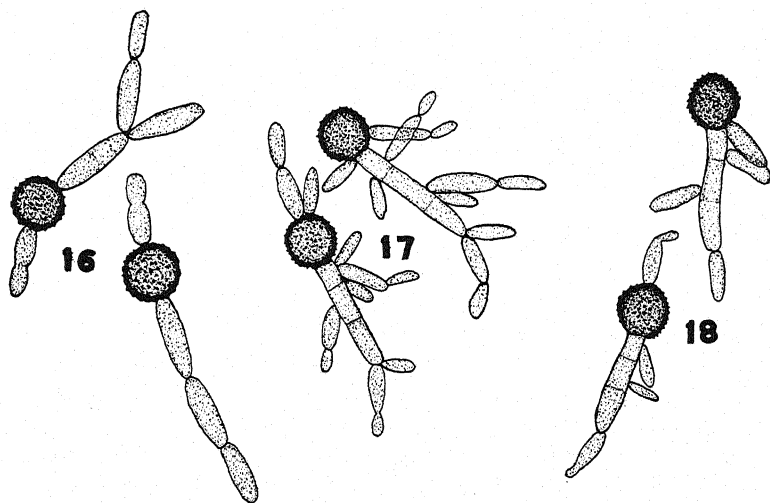
The remaining 4 collections, which were on *B. commutatus* and *B. secalinus*, did not differ from those on *B. mollis* and *B. carinatus* except that one specimen of *Ustilago bromivora* on *B. commutatus* had very minutely echinulate, almost smooth spores.

The 10 herbarium specimens of *U. Lorentziana* revealed no sig-

³ Plant Pathology Herbarium, State College of Washington.

⁴ Twenty spores from each specimen.

nificant differences either in average spore size, or character of the epispore. The averages for the 10 collections ranged from 7.71–9.08 μ in diameter and all were characterized by echinulate-verrucose or verrucose spores. One specimen of *U. Lorentziana*, on *Agropyron caninum* (L.) Beauv. (probably *A. subsecundum*) collected at Little Laramie River, Wyoming, August 18, 1911, by E. T. and E. Bartholomew (Fungi Columb. No. 3796), is of especial interest since the smutted spikes were very similar to those of *A. subsecundum*, affected with *U. bullata*. The other 9 collections were on *Hordeum jubatum*, but the spores of these had the same morphology as the one on *Agropyron caninum*.



FIGS. 16–18. 16, Typical germinating spores of collection M-B of *Ustilago bromivora* from *Bromus mollis* (not all collections of *U. bromivora* germinate in this manner; some more closely resemble the following two); 17, germinating spores of *U. bullata* (collection N-A) from *Agropyron pauciflorum*; 18, *U. Lorentziana* (collection R-A) from *Hordeum nodosum*. All drawn from photomicrographs, having good detail, but which were too hyaline to reproduce well in publication. \times about 700.

Except for being slightly smaller, the spores of the three herbarium specimens of *Ustilago bullata* examined revealed no differences from the collections of *U. Lorentziana* described above.

SPORE GERMINATION

The spores of each of the 19 smut collections listed in Table 2 have been germinated on potato-dextrose agar, and comparisons

made with regard to the manner of germination and subsequent behavior. No significant differences in the germination process could be detected in the spores of these 19 smut collections. All germinated, on potato-dextrose agar, with the production of from 1-3, usually 2 promycelia, on which are borne, and budded off, the oblong to elliptical sporidia. When a single promycelium is produced, it is only 3-celled, with the spore acting as the fourth cell (FIG. 17, 18). Often, however, in some collections of *U. bromivora* especially, two indistinctly 2-celled promycelia are produced, and sporidia are budded off each of the 4 cells (FIG. 16). The two promycelia more often emerge opposite each other.

DISCUSSION

On the basis of the data presented, it seems apparent that there is a close morphological similarity and relationship among *Ustilago bromivora*, *U. bullata* and *U. Lorentziana*. However, different collections of *U. bromivora* sometimes show sufficient differences to render morphological separation possible. Were such treatment desirable, *Ustilago bromivora* could be split up into 2 or 3 or more species or varieties, on the basis of spore size and the character of the epispore, and such species or varieties would probably be as valid as many now existing in essentially all groups of fungi. It would seem desirable, however, that critical study of a group of fungi should lead toward simplification, rather than complication, of the nomenclature of that group.

In view of this, it seems feasible to consider the above-described smuts on brome grasses, barley grasses and wheat grasses as one morphological species. Fraser and Scott (6) tended in this direction when they recognized the distinct similarity of the slender wheat grass smut to the common panicle smut of brome grasses, and assigned the former to *U. bromivora*. The fact that Liro (9) has demonstrated the existence of specialized races in *U. bromivora* (and to which he gives specific rank) does not conflict necessarily with the desirability of considering the smuts of the two grass genera as the same species. Furthermore, since *U. bromivora*, *U. bullata*, and *U. Lorentziana* appear to be closely related, and are not distinguishable on real and constant morphological grounds, it seems advisable to include *U. Lorentziana* in the composite spe-

cies. Whether or not future investigations substantiate Liro's (9) demonstration of the specialization within *U. bromivora* should not alter the situation, for the modern trend in the taxonomic treatment of pathogenic fungi is in opposition to the delimitation of species on the basis of host specialization. Indeed, the preliminary results of the writer's inoculation experiments indicate that closely specialized physiologic races may occur in all three of the smut species under consideration. Such a condition would be quite comparable to that demonstrated for other smut species, as, for example, *Ustilago striaeformis* (Westd.) Niessl. (4).

If these smuts on *Agropyron*, *Bromus*, *Hordeum*, and *Elymus* are to be considered as one species the question arises as to the proper binomial. *Ustilago bullata* was described in 1855 by Berkeley; *U. bromivora* in 1867 by Fischer von Waldheim when he raised to specific rank the Tulasnes' *Ustilago carbo* var. *vulgaris* d. *bromivora*; and *U. Lorentziana* was described in 1880 by von Thümen.

Since *U. bullata* has priority over the other two names, it is here proposed that this name apply to the grass smuts under consideration. Furthermore this name has the distinct advantage of being descriptive, since the sori are characteristically bullate before they rupture to shed the spores. Accordingly, a description of *U. bullata* in the new concept of the species follows:

Ustilago bullata Berkeley. In Hooker, W. J. Flora of New Zealand 2: 196. 1855.

Syn. *Ustilago carbo* var. *vulgaris* d. *bromivora* Tul. Ann. Sci. Nat. III. 7: 81. 1847.

Ustilago bromivora (Tul.) Fisch. von Waldh. Bull. Soc. Nat. Mosc. 40: 252. 1867.

Ustilago Lorentziana Thüm. Flora 63: 30. 1880.

Ustilago bromivora macrospora Farl. Bull. Iowa Agr. Col. Bot. Dept. 1886: 59. 1887.

Cintractia patagonica Cooke and Mass. Grevillea 18: 34. 1889.

Ustilago Holwayi Dietel, Bot. Gaz. 18: 253. 1893.

Ustilago Agropyri Clinton,⁵ Trans. British Myc. Soc. 8: 98. 1922.

⁵ No species description published, but the name refers to *Ustilago bullata* on *Agropyron pauciflorum*.

Ustilago Bromi-arvensis Liro, Ann. Acad. Sci. Fenn. A, 17, 1-636. 1924.

Ustilago Bromi-mollis Liro, *Ibid.*

Ustilago patagonica (Cooke and Massee) Ciferri, Ann. Myc. 26: 32. 1928.

Sori in the spikelets, bullate, sometimes entirely involving the glumes, but more often only partially so, at first enclosed by a greyish membrane (the host epidermis) of varying strength according to host, but which sooner or later ruptures, exposing the powdery dark-brown to purple-black or black spore-mass; spores rather thick-walled, mostly globose to subglobose, but often, especially in agglutinated or not fully mature specimens, tending to be irregular or polyhedral, usually dark brown or olive-brown, with an epispore varying from very minutely echinulate-verrucose to rather coarsely verrucose, 5-14 μ in diameter, more often 7-9 μ , not including the occasional elongate and irregular spores nearly always present. Germination of the indirect type, resulting in 1-3 promycelia, which are 1 to 3-celled, and bearing ellipsoid to oblong sporidia at tips and often just below cross-walls.

On Gramineae:⁶

| | | | |
|-------------------------------|------|--------------------------------|----------|
| <i>Agropyron cristatum</i> | (5) | <i>Bromus polyanthus</i> | (3) |
| <i>Agropyron dasystachyum</i> | (6) | <i>Bromus pumpellianus</i> | (3) |
| <i>Agropyron Griffithsii</i> | (12) | <i>Bromus racemosus</i> | (3) |
| <i>Agropyron pauciflorum</i> | (6) | <i>Bromus secalinus</i> | (3) |
| <i>Agropyron subsecundum</i> | (6) | <i>Bromus squarrosus</i> | (5) |
| <i>Bromus arduensis</i> | (5) | <i>Bromus sterilis</i> | (5) |
| <i>Bromus arvensis</i> | (3) | <i>Bromus tectorum</i> | (7) (16) |
| <i>Bromus brachystachys</i> | (5) | <i>Bromus vulgaris</i> | (3) |
| <i>Bromus breviaristatus</i> | (3) | <i>Bromus vulgaris eximius</i> | (3) |
| <i>Bromus brizaeformis</i> | (5) | <i>Elymus striatus</i> | (5) |
| <i>Bromus carinatus</i> | (3) | <i>Hordeum caespitosum</i> | (3) |
| <i>Bromus catharticus</i> | (5) | <i>Hordeum gussoneanum</i> | (8) |
| <i>Bromus ciliatus</i> | (3) | <i>Hordeum jubatum</i> | (3) |
| <i>Bromus erectus</i> | (5) | <i>Hordeum marinum</i> | (3) |
| <i>Bromus inermis</i> | (14) | <i>Hordeum murinum</i> | (3) |
| <i>Bromus japonicus</i> | (5) | <i>Hordeum nodosum</i> | (3) |
| <i>Bromus Kalmii</i> | (3) | <i>Hordeum pusillum</i> | (3) |
| <i>Bromus marginatus</i> | (3) | <i>Sitanion hystrix</i> | (7) |
| <i>Bromus mollis</i> | (3) | | |

⁶ Hitchcock's "Manual of the Grasses of the United States" (U. S. Dept. Agr. Misc. Publ. 200, 1935) has been followed in attempting to determine the correct names for these grass hosts. Synonymy is not shown. No distinction is made here between native and introduced species, and only those hosts reported in North America are listed.

An examination of a type specimen of *Ustilago bromivora* var. *macrospora* received from Dr. G. P. Clinton, Connecticut Agricultural Experiment Station, showed that the spores were quite large, varying from 8–14 μ , with the mode for diameter at 11 μ , and the mean at 11.38 μ .⁷ It is, therefore, larger than any of the collections of brome grass smut described in the preceding pages. Perhaps this collection is distinct enough to merit recognition as a variety. If so, should the collections M-J, and possibly also M-H and M-O (see Tables 2 and 3) be considered as the variety *macrospora* because of their large spores? Should, then, the collections M-K, M-A, and M-N be considered also as a variety because of their small spores, perhaps as var. *microspora* var. nov.? It is evident that there is far too much variation in size, shape, and surface markings of the spores to permit of such varieties being sharply delimited. It would seem best, therefore, to include *Ustilago bromivora* var. *macrospora* in the synonymy of *U. bullata* and recognize the latter as a composite species, probably consisting of many physiologic races possibly more or less sharply limited in host range, with these races sometimes morphologically more or less distinct on the basis of size and surface markings of the spores. Such a condition would be entirely comparable to that of some of the cereal and grass rusts, especially *Puccinia graminis* Pers. and *P. rubigo-vera* (DC.) Wint., and to the situation existing in wheat bunt, *Tilletia levis* Kühn. and *T. Tritici* (Bjerk.) Wint.

SUMMARY

This paper deals with the comparative morphology and taxonomic relationships of the smuts of barley grasses, brome grasses, and wheat grasses in the Northwest heretofore known under the names *Ustilago Lorentziana*, *U. bromivora*, and *U. bullata*, respectively.

Examination of 19 current collections, and 41 herbarium specimens of these three smuts revealed that they are morphologically

⁷ Based on 100 spores (see Table 3). These measurements do not agree with those given by Clinton (3) who states that the spores are "somewhat more irregular and larger, chiefly 11–17 μ in length." This discrepancy is probably due in part, at least, to the fact that in the present studies only diameters were considered.

similar. There is more variation in the morphology of the spores of collections of *U. bromivora* than exists between *U. bromivora*, as a species, and either *U. bullata* or *U. Lorentziana*.

The modes for the diameter of the spores of various collections of *U. bromivora* ranged from 6μ in collection M-K to 10μ in collections M-J and M-H. The mode for spore diameter of *U. bullata* was 7μ in 3 collections and 8μ in a fourth; for *U. Lorentziana* it was 8μ in all collections.

In *U. bromivora* the epispore also varied according to collection from very minutely echinulate-verrucose in collection M-K to rather coarsely verrucose in collection M-L. Most collections were distinctly echinulate-verrucose. *U. bullata* and *U. Lorentziana* showed less variation, from finely echinulate-verrucose to minutely verrucose.

It is considered that the smuts under the names *Ustilago bromivora*, *U. bullata*, and *U. Lorentziana* really represent one composite species, probably containing numerous well-defined physiologic races. Since *U. bullata* has priority over the other two names and is descriptive of the sori, it is proposed that that name apply to this species.

An emended description of *Ustilago bullata* is accordingly given, with a list of the hosts in North America. Thus, 5 species of *Agropyron*, 23 species of *Bromus*, 1 of *Elymus*, 7 of *Hordeum*, and 1 of *Sitanion* are recognized as hosts to *U. bullata*, in the new concept of this species. Ten of this total of 37 grasses are herein reported for the first time.

LITERATURE CITED

1. Berkeley, M. J. In Hooker, W. J. Flora of New Zealand 2: 196. 1855.
2. Ciferri, R. Quinta contribuzione allo studio degli Ustilaginales. Ann. Myc. 29: 67. 1931.
3. Clinton, G. P. Ustilaginales. N. Am. Flora 7: 1-82. 1906.
4. Davis, W. H. Summary of investigations with *Ustilago striaeformis* parasitizing some common grasses. Phytopath. 25: 810-817. 1935.
5. Fischer, G. W. Observations on the comparative morphology and taxonomic relationship of certain grass smuts in Western North America. (The present paper, cited herein where the hosts of *Ustilago bullata* are listed.)

6. Fraser, W. P. & Scott, G. A. Smut of western rye grass. *Phytopath.* 16: 473-477. 1926.
7. Garret, A. O. Smuts and rusts of Utah. IV. *Mycologia* 13: 101-110. 1921.
8. Lefebvre, C. L. & Johnston, C. O. Kansas Mycological Notes, 1934. *Trans. Kansas Acad. Sci.* 38: 101-103. 1935.
9. Liro, J. I. Die Ustilagineen Finnlands. I. *Ann. Acad. Sci. Fenn., Serie A.* 17: 1-636. 1924.
10. McAlpine, D. The smuts of Australia. vi + 288 pp. 1910.
11. Mourashkinsky, K. E. (Loose smut of American rye grass.) *Trans. Siberian Acad. Agr. and Forestry* 6: 1-4. 1926. (In Russian, German summary; English title from *Rev. Appl. Mycol.* 6: 293-294. 1927.)
12. Padwick, G. W. & Henry, A. W. Studies on the temperature and host relations of *Ustilago bromivora* (Tul.) Fisch. v. Waldh. causing smut of *Agropyron* species. *Proc. World's Grain Exhib. Conf., Canada* 2: 248-253. 1933.
13. Pammel, L. H., Weems, J. B., & Lamson-Scribner, F. Grasses of Iowa. *Iowa Agr. Col. Exp. Sta. Bull.* 54. 1901.
14. Seymour, A. B. Host index of the fungi of North America. xiii + 732 pp. 1929. Harvard University Press, Cambridge, Mass.
15. Zundel, G. L. Some Ustilagineae of the State of Washington. *Mycologia* 12: 275-281. 1920.
16. —. Smuts and rusts of northern Utah and southern Idaho. *Mycologia* 13: 179-183. 1921.

NEW OR NOTEWORTHY PARASITIC SPECIES OF FUNGI IMPERFECTI IN OREGON¹

RODERICK SPRAGUE

The fungi that are described or discussed in this paper are deposited in the Mycological Herbarium of the Department of Botany at Oregon State College, Corvallis. Portions also have been deposited in the Mycological Collections of the Bureau of Plant Industry, U. S. Dept. of Agriculture, Washington, D. C. All of the collections at Corvallis are numbered (*i.e.* Ore. 10,615). Most of these fungi are from undetermined collections referred to the writer for determination.

Phyllosticta Barssii sp. nov.

Maculis pallido-brunneis, orbicularibus v. subconfluentibus; pycnidiiis brunneis globosis v. subglobosis, punctiformibus, ostiolatis, $75-140 \times 85-200 \mu$; sporulis bacillaribus, hyalinis, $2.8-4.2 \times 0.4-0.7 \mu$.

Hab. in foliis vivis *Saussureae americanae* D. C. Eaton.

Spots tan to brown with darker borders, circular, 4-8 mm. in diameter later larger and angular becoming confluent, partially restricted by the veins, pycnidia epiphyllous, numerous, prominent, punctiform, erumpent, brown, globose to irregular, thin walled, ostiolate, $75-140 \times 85-200 \mu$; pycnospores minute, bacteria-like, $2.8-4.2 \times 0.4-0.7 \mu$, hyaline, cylindrical, straight or slightly curved, sometimes two-celled or bi-guttulate, mostly non-septate.

On living leaves of *Saussurea americana* D. C. Eaton. Whitewater Ranger Station, Cascade Mts., Ore. Collected by H. P. Barss and G. B. Posey, Aug. 16, 1914 (Ore. 10,536). Barss states that Whitewater Creek is one of the glacier-fed streams coursing down Mt. Jefferson into the Santiam River, the collection having

¹ Coöperative investigations between the Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, and the Department of Botany, Oregon Agricultural Experiment Station, Corvallis, Ore. Published as Technical Paper No. 262 of the Oregon Agricultural Experiment Station.

been made about ten miles west of Mt. Jefferson. *P. Barssii* appears to be the first parasitic fungus described on this alpine species of plant.

***Ascochyta Abroniae* sp. nov.**

Maculis stramineis v. brunneis, orbicularibus v. ellipticis, 2-8 mm. diam.; pycnidiis erumpentibus, gregariis, numerosis, conspicuis, aureis, ostiolatis, 100-170 μ diam.; pycnosporulis rectis, cylindraceis, utrinque rotundatis, hyalinis, 1(1-2) septatis, 15-26 \times 4.5-6 μ .

Hab. in foliis vivis *Abroniae melliferae* Dougl.

Lesions circular to elliptical, straw colored but appearing speckled brown on account of the numerous large gregarious pycnidia which are erumpent, globose, golden brown with a prominent dark ring of cells around the ostiole; ostiole 4-6 μ in diameter, slightly elongated or nipple-like; pycnidia 100-170 μ in diameter; sometimes two or three pycnidia coalesced; pycnospores hyaline, cylindrical or slightly tapering, constricted at the septum, 1- (rarely 2-) septate, ends rounded, 15-26 (mostly 18-25) \times 4-5 μ .

On living leaves of *Abronia mellifera* Dougl. Hermiston, Ore. Collected by H. S. Jackson, May 12, 1915 (Ore. 10,763).

This fungus occurs on a species of *Abronia* growing in almost dune-like stretches of sandy soil in the sagebrush region of north central Oregon. The only comparable fungi on the Nyctaginaceae are *Ascochyta Orybaphi* Trel. on *Orybaphus* and *A. Boerhaaviae* Tharp on *Boerhaavia*. The first mentioned species has spores measuring 10-17 \times 4 μ and the latter has still smaller spores, 12-14 \times 3.5-4 μ . There are no species of the Sphaeropsidales listed on the genus *Abronia* in available literature.

ASCOCHYTA ACHLYDIS

Ascochyta Achlydis Dearn. on *Achlys triphylla* (Smith) DC. collected at Diamond Lake, Ore., by L. N. Goodding (Ore. 10,516) in July 1931 had pycnospores which averaged 65 per cent 1-septate and 35 per cent 2-septate. The spores with one septum average 16-29 \times 5.8-8.5 μ and those with two septa average 22-31 \times 6-9 μ ; pycnidia 150-300 μ in diameter arranged concentrically near the center of the lesions. Dearness' measurements (14-20 \times 5-6.5 μ) are those of considerably smaller spores but a comparison of Goodding's collection with others made in Oregon

indicate that Dearness' type collection represents a smaller stage, possibly immature, of the same species as that of Goodding's collection.

The fungus is one of the robust species of *Ascochyta* which some workers put in the intermediate genus *Stagonosporopsis*. Since approximately two spores out of three are typically *Ascochyta* the writer arbitrarily leaves the fungus in this genus. The writer is aware, however, that some will prefer *Stagonospora Achlydis* (Dearn.) comb. nov., which he does not.

***Ascochyta Hydrophylli* sp. nov. Sprague & Bailey**

Maculis cinereis v. nigris, orbicularibus dein confluentibus, 3-10 mm. diam.; pycnidiiis sparsis, non gregariis, globosis, aureis, ostiolatis, obscuris, 75-100 \times 80-115 μ diam.; pycnosporulis rectis, cylindraceis, utrinque rotundatis, hyalinis, 1-septatis, 11-14 \times 1.8-2.7 μ (12-13 \times 2.2-2.4 μ).

Hab. in foliis vivis *Hydrophylli tenuipedis* Heller.

Lesions grey to sordid black, circular becoming confluent, 3-10 mm. diameter, frequently coalescing to cover entire surface of leaf lobes; pycnidia scattered, obscure, erumpent-superficial, globose, thin-walled, of loosely constructed pale yellow rectangular cells, ostiole obscure and poorly differentiated; pycnidia 75-100 \times 80-115 μ in diameter; pycnospores straight, cylindrical, both ends rounded, hyaline, 1-septate, 11-14 \times 1.8-2.7 μ (mostly 12-13 \times 2.2-2.4 μ).

On living leaves of *Hydrophyllum tenuipes* Heller, Corvallis, Ore. Collected by Floyd D. Bailey, May 19, 1913 (Ore. 10,594).

Gloeosporium Hydrophylli Dearn. and House has spores measuring 5-9 \times 2-2.5 μ borne in acervuli found in zonate spots. There are no other comparable species described on the Hydrophyllaceae.

STAGONOSPORA GLYCERIAE Roum. & Fautr.

This fungus causes a buff to tawny, later white lesion on *Glyceria striata* (Lam.) Hitchc. This fungus was collected near Hoover, Ore., by Posey and Barss in Aug. 1914 (Ore. 10,177), apparently its only report for North America. Detailed studies are needed on the *Stagonospora* spp. on Gramineae. The Oregon collection is referable to the species described as *S. Glyceriae*.

Septoria Poseyi sp. nov.

Maculis brunneis, margine subdistincto; pycnidiis sparsis, indistinctis, epiphyllis, erumpentibus, punctiformibus, subglobosis, 80–170 μ diam. subnigris, ostiolatis; pycnosporulis filiformibus, subflexuosis, utrinque obtusis, hyalinis, 1–3–(4–) septatis, 32–58 \times 1.4–2.2 μ .

Hab. in foliis vivis *Mertensiae laevigatae* Piper.

Spots brown with a subdistinct margin, pycnidia few, obscure, epiphyllous, erumpent, punctate and subglobose, 80–170 μ in diameter, black-brown, ostiolate, pycnospores filiform, subflexuous, ends rounded, hyaline, 1–3–(4–) septate, 32–58 \times 1.4–2.2 μ .

On living leaves of *Mertensia laevigata* Piper. Whitewater Ranger Station, Ore. Collected by G. B. Posey and H. P. Barss, Aug. 16, 1914 (Ore. 10,534).

The pycnospores of *S. Poseyi* range almost exactly intermediate in size between *S. Drygalski* P. Henn. (60–80 \times 2–2.5 μ) and *S. Stenhammariae* Rostr. (25–30 \times 1 μ). These latter two species occur on *Mertensia maritima* (L.) S. F. Gray, which grows along the seacoast of the North Atlantic. Since the spores of *S. Poseyi* appear to be mature, it is considered a distinct species rather than a variety of *S. Drygalski*. The spores of these two species are distinct in size and the habitats of the fungi are very different, one being found in the high mountains, the other near sea level.

Septoria umatillensis sp. nov.

Maculis pallide brunneis dein albis, margine brunneo, irregularibus v. subrotundatis, 3–12 mm. diam.; pycnidiis obscuribus, globosis, nigris, 80–155 \times 80–160 μ diam.; ostiolis obscuribus; pycnosporulis hyalinis, curvulis, filiformibus-cylindraceis, cacumine acutis, basis hebitibus, 1-septatis, 26–35 \times 2.9–4.3 μ .

Hab. in foliis vivis *Psoraleae lanceolatae* var. *scabrae* (Nutt.) Piper.

Spots pale brown, finally white, margins brown sometimes slightly raised, irregular to sub-rotund, 3–12 mm. diam.; pycnidia obscure, scattered among the much more prominent glands of the host, black, depressed and slightly erumpent, globose or slightly flattened, with walls of closely knitted, deeply pigmented cells, 80–155 \times 80–160 μ diam.; ostioles small and obscure and appearing late or absent; pycnospores hyaline, curved, filiform-cylindric, apex acute, base broader, rounded with ends blunt, 1-septate, 26–35 \times 2.9–4.3 μ .

On living leaves of *Psoralea lanceolata* var. *scabra* (Nutt.) Piper. Hermiston, Ore. Collected by H. S. Jackson, May 12, 1915 (Ore. 10,762).

Septoria Argophyllae E. and K. on *Psoralea argophylla* is characterized by minute spots (1 mm.) and sepia-colored, immersed pycnidia with cylindrical, obtuse, 2-3-septate spores measuring $40-55 \times 2.5-3 \mu$. The greater size and more numerous septa of the spore indicate that *S. Argophyllae* is distinct from *S. umatillensis*. However, study with viable material is needed.

S. umatillensis derives its specific name from the region wherein it was collected. This area along the Umatilla river in Umatilla County, Oregon, was once occupied by the Umatilla tribe of Indians.

DILOPHOSPORA ALOPECURI (Fries) Fries

This fungus is very common in late winter and early spring on *Holcus lanatus* L. in western Oregon but it has not been reported on any other hosts from this area. The fungus is apparently the same as *D. graminis* Desm. f. *holci* Fuckel (*D. Holci* Fuckel) on *Holcus lanatus* in Europe. Indications are that this fungus and the one that attacks cereals in Europe are two physiologic races of the same species. The species name, *alopecuri*, is preferred because, as pointed out by Atanasoff,² it has priority over the others.

Ramularia Giliae sp. nov.

Maculis obscuribus, luteo-brunneis, epiphyllis; conidiophoris conferto-fasciculatis, hyalinis, cylindraco-clavatis v. geniculatis, plerumque, continuis, stromate hyalino ortis, $30-45 \times 3-4 \mu$; conidiis 1-septatis, constrictis, cylindracois v. obclavatis, hyalinis, $16-38 \times 4-6 \mu$.

Hab. in foliis *Giliae bicoloris* (Nutt.) Piper.

Lesions obscure, epiphyllous, buff, usually covering the entire leaf, conidiophores densely fascicled in numerous groups, uniformly and densely scattered over the leaves; conidiophores hyaline, cylindrical-clavate, sometimes geniculate, usually continuous, arising from a substantial hyaline stroma, $30-45 \times 3-4 \mu$; conidia borne in short chains, cylindrical to slightly obclavate or clavate, mostly one septate, constricted at septum, hyaline, $16-38 \times 4-6 \mu$.

On leaves of *Gilia bicolor* (Nutt.) Piper. Near Corvallis, Ore. Collected by H. S. Jackson, May 1, 1915 (Ore. 10,615).

² Atanasoff, D. The *Dilophospora* disease of cereals. Phytopath. 15: 11-40. 1925.

This fungus, which was collected over twenty years ago, is apparently common but the small size of the host, particularly the leaves, and the hyaline nature of the fungus has permitted the disease to escape observation by all other collectors. Only a careful observer would detect it in the field.

***Ramularia Vancouveriae* (Ellis & Ev.) comb. nov.**

This fungus on *Vancouveria hexandra* (Hook.) Morr. and Dec., collected by H. S. Jackson on Mary's Peak (Benton Co.) on Aug. 15, 1914 (Ore. 10,600), has cylindrical, catenulate, hyaline spores, one to three septate, $18-29 \times 4-5.7 \mu$, and borne on fascicled tapering conidiophores, which arise from a distinct sub-stomatal stroma. At a magnification of $20\times$, the fascicles are visible as slightly roughened, uniformly distributed places on the under surface of small angular buff lesions. The fungus, which has been called *Ovularia Vancouveriae* Ellis & Ev., obviously belongs in the genus *Ramularia*, as shown by comparison with the type, and therefore it is transferred to that genus.

***Cercospora praegrandis* sp. nov.**

Maculis rotundatis v. irregularibus, brunneis; myceliis vegetis chlorinis v. brunneis, septatis, ramosis; myceliis stromatis nigris; conidiophoris brevibus raro longis; conidiis raris, pallide brunneis, subulato-filiformibus, curvulis, pluriseptatis, constrictis (cellulis doleiformibus), fragilibus, $150-270 \times 9-14 \mu$.
Hab. in foliis vivis *Osmorhizae brevipedis* (Coult. & Rose) Suks.

Lesions circular to irregular, brown to chocolate brown; vegetative mycelium chlorinous to brown, branched, septate; stromatic mycelium becoming black, aggregated at or near the leaf surface from which short to sometimes extended conidiophores arise; conidia not abundant, pale brown, subulate-filiform, base blunt, tapering to a whip-like distal portion, which is usually strongly curved; conidia multiseptate, with as many as 16 septa, constricted at central septa (cells sometimes barrel-shaped) fragile, of great size $150-270 \times 9-14 \mu$.

On living leaves of *Osmorhiza brevipes* (Coult. and Rose) Suks. On moist shaded bank, Yew Creek near upper (highway) bridge, Alsea Mountain (Benton Co.) Ore. Collected by R. Sprague, April 25, 1936 (Ore. 10,664).

This species has gigantic conidia, which are far larger than any other species of *Cercospora* described on the Umbelliferae. *C. Osmorhizae* Ellis & Ev. has spores $80-120 \times 3-4 \mu$, thus averaging about half as long and a third as wide as *C. praegrandis*.

***Cercospora daemonicola* sp. nov.**

Maculis irregulariter zonatis, nigro-brunneis, centro pallidioribus, angularibus, irregularibus v. subrotundatis, epiphyllis, margine angusto, 2-14 mm. diam.; myceliis vegetis chlorino-olivaceis v. brunneis, $2.5-6 \mu$ diam., septatis, ramosis; myceliis stromatis brunneis; conidiophoris brevibus $10-25 \times 4-6 \mu$ v. longis (120μ); conidiis olivaceo-chlorinis subulato-filiformibus, curvulis, parte superiore in flagellam exilissimam extenuata, pluriseptatis (8-10), fragilibus, $120-203 \times 8-15 \mu$.

Hab. in foliis vivis *Oplopanax horridi* (Sm.) Miquel.

Spots dark brown to inky with 2 to 5 irregular zonations, centers lighter brown; spots irregular, angular or subrotund, variable in size from 2 to 14 mm. or larger where coalesced, with a narrow, black, or sepia margin, epiphyllous; vegetative mycelium prominent, yellowish to olive or brown, $2.5-6 \mu$ diameter, septate, branched, developing throughout the leaf tissue and aggregating near or at the upper leaf surface forming small to medium sized brown stroma from which single or somewhat fascicled conidiophores arise, usually $10-25 \times 4-6 \mu$, but sometimes apparently much longer (120μ); conidia olivaceous-chlorinous but not brown, subulate-filiform, curved with the upper half of the spore tapering into a whip-like, usually non-septate chlorinous tip, basal end rounded but with a flattened hilum, 8-10 septate when mature, mostly nine septate, large and fragile, $120-203 \times 8-15 \mu$.

On living leaves of *Oplopanax horridum* (Sm.) Miquel (Devil's Club) associated in part with saprophytic (?) fungi in the lesions. Middle fork of the South fork of the Santiam River two miles above its junction with Quartz Creek, Linn. Co., Ore. Collected by R. Sprague and F. D. Bailey, July 18, 1936 (Ore. 10,915).

Cercospora Araliae P. Henn., which was described on *Aralia spinosa* in Japan, is produced in fuscus lesions on the underside of the leaves and differs from *C. daemonicola* in having very much smaller spores, $30-70 \times 4.5-5.5 \mu$ ($30-60 \times 5-6 \mu$ on *A. sinensis*). *C. atromaculans* Ellis & Ev. also has been reported on *A. spinosa* (Louisiana), is amphigenous, with spores $40-75 \times 3-4 \mu$. *Cercospora leptosperma* Peck, which was described on *A. nudicaulis*

from Iowa, produces light green spots and has paler conidia and mycelium (*Cercospora*), and also has much smaller conidia (75 μ long) than *C. daemonicola*. It seems, therefore, that *C. daemonicola* is distinct from any species of *Cercospora* previously described on any member of Araliaceae.

The writer is indebted to his colleagues, A. G. Johnson and Edith Cash, for kindly suggestions in the preparation of the descriptions.

NOTES ON THE PARASITIC FUNGI OF ILLINOIS—VI

LEO R. TEHON

(WITH 9 FIGURES)

In this, as in the previous papers of this series,¹ the purpose is to record plant inhabiting, apparently parasitic fungi that are deemed deserving of recognition as new species; but opportunity is being taken, also, to report in analytical keys the results of comparisons made of old species and to incorporate data as to host range and geographic occurrence.

As formerly, Gray's New Manual of Botany, Seventh Edition, has furnished the nomenclature of wild plants and Bailey's Manual of Cultivated Plants that of crop plants. Besides the usual data as to place and date of collection, each specimen referred to is designated by its accession number in the Mycological Collection of the Illinois State Natural History Survey. Excerpts from type specimens, whenever the material at hand permits, have been deposited in The New York Botanical Garden's herbarium.

***Mycosphaerella Holci* sp. nov.**

Folicle; inhabiting very extensive tan to stramineous red-bordered areas; perithecia innate, developed in and occupying the mesophyll, spherical, membranous, 60–100 μ in diameter, opening hypophyllously; ostiole papillate, usually about 15 μ high, the pore 7–10 μ wide. Asci cylindrical to clavate, 30–45 \times 8–12 μ , apara-physate, 8-spored; ascospores 12–15 \times 5–6 μ , biseriate, 1-septate, constricted at the septum, hyaline, upper cell somewhat the larger (FIG. 5, 6).

Maculis in foliis extantissimis brunneolis usque stramineis annulo miniato cinctis, peritheciiis innatis in medietate folii sitis sphaericis membranaceis 60–100 μ diametris per paginam inferam pertundentibus, ostiolis papilliformibus plurimum circa 15 μ altis cum poro 7–10 μ lato, paraphysibus carentibus, ascis cylindricis usque clavatis 30–45 μ longis 8–12 μ latis octosporis, asco-

¹ *Mycologia* 16: 135–142. 1924; *ibid.* 17: 240–249. 1925; *ibid.* 19: 110–129. 1927; *ibid.* 21: 180–196. 1929; and *ibid.* 25: 237–257. 1933.

sporis hyalinis distichis semel septatis loculo supero paulo majore angustioribus ad septum $12-15\ \mu$ longis $5-6\ \mu$ latis.

On living leaves of *Holcus Sorghum* L., var. *technicus* (Körn. & Wern.) Bailey (broom corn) near Oakland, Coles County, Ill., October 5, 1927, Acc. No. 11591 (type); and near Mattoon, Coles County, Ill., October 5, 1927, Acc. No. 11682.

In the same material, in the same spots, and scattered among the perithecia, occur also the pycnidia of a *Phyllosticta*. These are of about the same size as the perithecia, light brown and membranous, with ostioles up to $15\ \mu$ wide which open through stomata in the lower leaf surface. The spores are oblong with rounded ends, often somewhat curved, biguttulate, and $6-7 \times 3-3.5\ \mu$. From the description of *P. sorghina* Sacc., supposedly a spermatogonial stage of *Sphaerella Ceres* Sacc., they appear referable to that species even though the spores are larger. Their constant occurrence with the perithecia suggests that they may be the imperfect spore form.

The ascomycete has several points in common with the *Sphaerella Ceres* Sacc. reported on *Sorghum vulgare* from Italy, the pycnidial stage of which is reported to be *Ascochyta Sorghi* Sacc. Not having been able to see type or other authentic material of Saccardo's fungus, nor to be certain that our fungus is the same as that so briefly described by Saccardo, we propose it as a separate species, the name for which can readily be reduced to synonymy in the event that the two prove identical.

***Glomerella vignicaulis* sp. nov.**

Perithecia on dead stems, scattered and sparse, or abundant, clustered, contiguous, or even sometimes apparently confluent, spherical to somewhat applanate, dark brown but membranous, $130-230\ \mu$ in diameter; ostiole short-papillate, round, more or less carbonized, $25-35\ \mu$ in diameter; paraphyses lacking; asci clavate, broadest above the middle, tapered thence to a broad, coarse foot, thickened at the rounded apex and provided with a pore for the emission of spores, $45-50\ \mu$ long, $10-12\ \mu$ wide, 8-spored; ascospores biseriate, hyaline, allantoid, non-septate in the ascus, often becoming 1-septate after discharge, slightly constricted at the septum, $10-18.5\ \mu$ long, $3-4.5\ \mu$ wide, mostly $14-16 \times 3.5\ \mu$ (FIG. 3, 4).

Peritheciis in caulibus emortuis sparsis et conspersis vel abundantibus congregatis contiguis vel etiam nonnumquam aperte confluentibus sphaericis usque paulo applanatis atratis brunneis sed membranaceis 130–230 μ diametris, ostiolis nonnihil papilliformibus rotundatis plus vel minus carbonaceis 25–35 μ diametris, paraphysibus carentibus, ascis clavatis latissimis supra medium attenuatis inde ad pedem latum magnum incrassatis ad apicem rotundatum et munitis cum poro ut sporas emittant 45–50 μ longis 10–12 μ latis octosporis, ascosporis biseriatis hyalinis allantoideis non septatis inasco saepe semel septatis post effusionem leniter angustioribus ad septum 10–18.5 μ longis 3–4.5 μ latis ut plurimum 14–16 \times 3.5 μ .

On *Vigna sinensis* Endl. (cowpea) near Equality, Gallatin County, Ill., Sept. 8, 1932, Acc. No. 23703 (type); near Carmi, White County, Ill., Sept. 10, 1934, Acc. No. 24809; and near Olmstead, Pulaski County, Ill., Sept. 17, 1933, Acc. No. 25450.

Glomerella cingulata (Stonem.) Sp. & v. Schr. has been reported on various members of the legume family, notably *Gleditsia triacanthos*, *Brya Ebenus*, *Lathyrus odoratus*, *Glycine hispida*, *Phaseolus lunatus*, and *P. vulgaris*; and *Glomerella lindemuthianum* Shear has been reported on *Vigna sinensis*. The apparently closely related *Phomatospora Wistariae* Ellis & Ev. occurs on *Wisteria frutescens*. The conidial stage of the first is a *Gloeosporium* and that of the second is a *Colletotrichum*. None is known for the third.

In each collection, this fungus is accompanied by a *Cercospora* exceptional in the length of its conidiophores and in that its spores, though variable, are in the main very long, very fine, and slender. Also, the conidiophores are borne in groups on cellular stromata which are connected with and arise from deeply situated strands of brown mycelium, not separable under the microscope from that which gives rise to the perithecia. The two spore forms are intimately associated, and it seems clearly evident in microtome sections (FIG. 9) that they are connected. The *Cercospora* has the following diagnosis.

***Cercospora vignicaulis* sp. nov.**

Fascicles scattered, seated on complex globular to columnar cellular brown stromata 28–55 μ wide or much larger by confluence, bearing from 1 to 12 erect and straight, or divergent, brown conidiophores which are septate at intervals of about 15 μ in the basal half, 55–125 μ long, 5–6.6 μ wide at the non-bulbous base, tapering

only slightly (and becoming lighter brown and thinner walled) above, there $3.5\text{--}4\ \mu$ wide, commonly with 3 geniscars, 1 terminal and 2 lateral within $20\ \mu$ of the apex and generally all within $15\ \mu$. Conidia hyaline, very narrowly acicular, flexuous, terminally borne, septate, tapered from the base to a fine tip, conspicuous geniscar basal and internal, $60\text{--}245 \times 2.5\text{--}3.5\ \mu$. Mycelium mostly deep, cylindrical, septate, brown and translucent, but also forming abundant aliform strands and complexes (FIG. 7, 8).

Fasciis sparsis in stromate complicato globoso usque columnare brunneo $28\text{--}55\ \mu$ lato vel plus majore per confluentem ferente 1 usque 12 conidiophora erecta recta divergentia quae septata ad intervalla circa $15\ \mu$ in dimidio basilare $55\text{--}125\ \mu$ longa $5\text{--}6.6\ \mu$ lata ad basem non bullata attenuata solim leniter (denique dilute brunnea et tenuata lateribus) supra et ibi $3.5\text{--}4\ \mu$ lata cum 3 hilis 1 terminali et 2 in latere in $20\ \mu$ ab apice et plurime omnia in $15\ \mu$, conidiis hyalinis angustissime acicularibus flexuosis terminaliter nascentibus septatis attenuatis ex base ad apicem acutissimum, $60\text{--}245 \times 2.5\text{--}3.5\ \mu$, hilo conspicuo basilari et interno, mycelio plurime alte in caule sito cylindraceo septato brunneo et translucido sed etiam formanti funiculos abundantes aliformes et complicatos.

Phyllosticta atomata sp. nov.

Maculicole, the spots extending through the leaf, subcircular to irregular, cinereous, arid, $0.5\text{--}2$ mm. in diameter when within the blade, becoming confluent, when on the margins becoming very large, limited by a fine, raised, black line, this surrounded by a gradually diffusing purplish-brown halo; the tissue of the spot collapsing and cracking irregularly upon being dried. Pycnidia developed in and occupying the mesophyl, opening to either surface, spherical to applanate, membranous, brown, scattered but usually abundant, $40\text{--}70\ \mu$ in diameter; ostiole papillate, its opening $12\text{--}15\ \mu$ in diameter. Spores hyaline, non-septate, bacillar, $0.75\text{--}1\ \mu$ wide, $3\text{--}5\ \mu$ long.

Maculis in foliis amphigenis subrotundatis usque irregularibus cinereis aridis denique confluentibus $0.5\text{--}2$ mm. diametris in interiore maximis in marginibus folii angustissima elevata nigra linea limbatis et ex hac halos purpurea brunnea gradatim diffundens, telis macularum collabentibus et scindentibus irregulariter siccantibus, pycnidiis sparsis sed plurimum abundantibus brunneis sphaericis usque applanatis membranaceis in tela medii folii sitis per utramque paginam perrumpentibus $40\text{--}70\ \mu$ diametris, ostioliis papilliformibus cum oribus $12\text{--}15\ \mu$ diametris, sporulis hyalinis non septatis bacillaribus $3\text{--}5\ \mu$ longis $0.75\text{--}1\ \mu$ latis.

On living leaves of *Plantago Rugèlii* Dcne. near Elizabeth, Jo Daviess County, Ill., July 24, 1927, Acc. No. 10349 (type).

In adding this species to the list of Phyllostictae known on species of *Plantago*, the characteristics of the several parasites have been taken into consideration as follows:

Pycnidia not exceeding $100\ \mu$ in diameter.

Spores bacillar, about $1\ \mu$ wide.....*P. atomata*

Spores oval to oblong, $2-3\ \mu$ wide.

Spores allantoid, up to $9\ \mu$ long.....*P. plantaginella*

Spores oblong to ovoid, up to $5\ \mu$ long*P. Plantaginis*

Pycnidia $120\ \mu$ or more in diameter, spores $3-4\ \mu$ wide.....*P. plantaginicola*

***Macrophoma oblongata* sp. nov.**

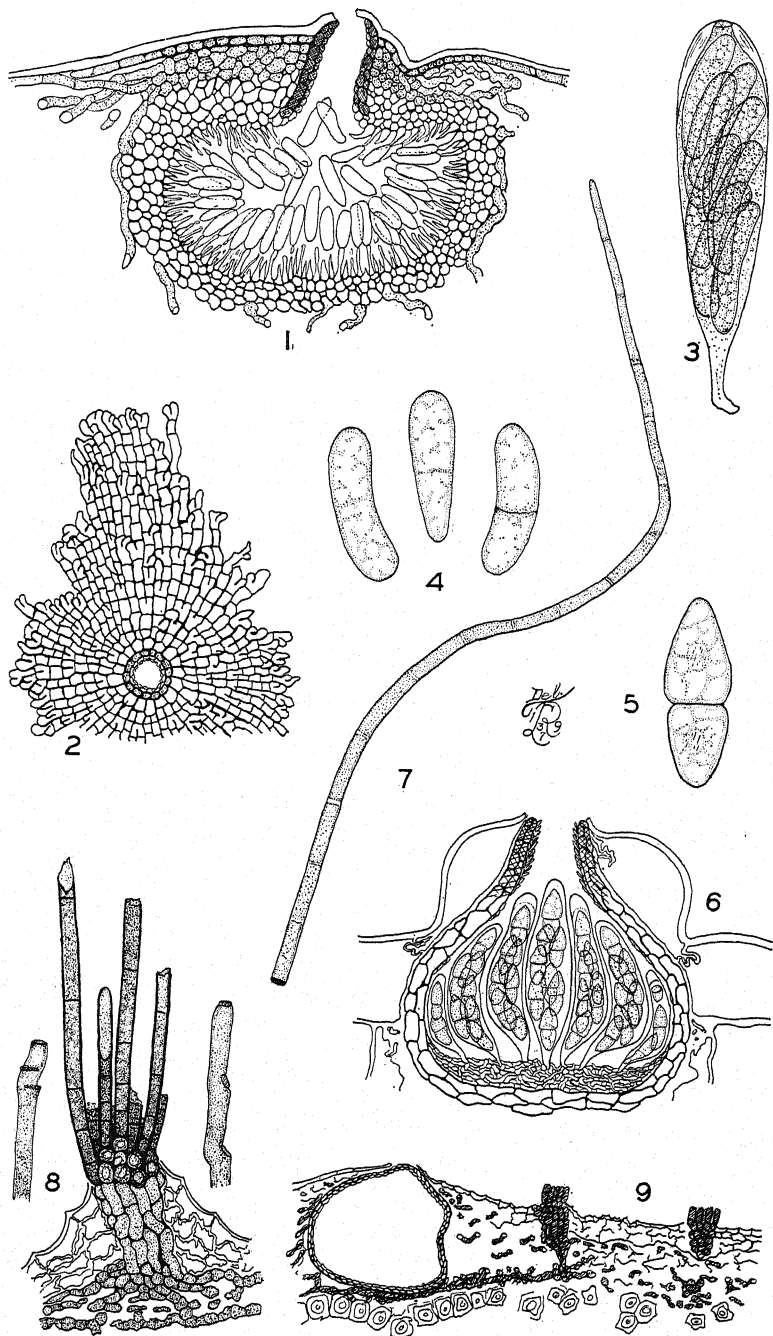
Pycnidia caulicolous but not in spots, oblong with bluntly rounded ends, oriented parallel with the stem and set in rows between the sclerenchyma strands, dark brown, membranous, and translucent, becoming carbonaceous and opaque, $95-135\ \mu$ wide, $200-500\ \mu$ long, usually discrete but occasionally joined terminally. Ostiole central, round, not papillate, the opening $20-25\ \mu$ in diameter. Spores hyaline, continuous, oblong-ovate, with rounded ends, $19-26 \times 6.5-8.5\ \mu$, borne on tapering conidiophores up to $10\ \mu$ long and $2.5-3\ \mu$ wide.

Pycnidiis in caulibus sed non in maculis, oblongis cum apicibus rotundato-obtusis parallelis cum caule orientibus et in serie inter strias sclerenchymatis ordinatis atratis brunneis membranaceis et translucidis denique carbonaceis et opacis $95-135\ \mu$ latis $200-500\ \mu$ longis ut plurimum discretis sed nonnumquam iunctis terminaliter, ostiolis centralibus rotundatis non papilliformibus cum foramine $20-25\ \mu$ diametro, sporulis hyalinis continuis oblongis-ovatis cum apicibus rotundatis $19-26\ \mu$ longis $6.5-8.5\ \mu$ latis in basidiis attenuatis usque $10\ \mu$ longis $2.5-3\ \mu$ latis nascentibus.

On *Poa pratensis* L. near Rushville, Schuyler County, Ill., August 2, 1935, Acc. No. 25381 (type).

***Macrophoma secalina* sp. nov.**

Not maculicole. Pycnidia separate and scattered, amphigenous on leaves, spherical to decidedly applanate or almost dimidiate, dark brown to black, membranous and translucent to heavily carbonized and opaque, $145-260\ \mu$ in diameter, ostiolate, apparently subcuticular and developed from a subcuticular plate of aliform mycelium. Ostiole circular, carbonized, somewhat papillate, $20-25\ \mu$ in diameter. Spores hyaline, oblong to somewhat pyriform, rounded above, with a short but well defined basal stalk, $19-30 \times 6.5-10\ \mu$; conidiophores simple, hyaline, nonseptate, often



FIGS. 1-9. 1-2, *Macrophoma secalina*; 3-4, *Glomerella vignicaulis*; 5-6, *Mycosphaerella Holci*; 7-8, *Cercospora vignicaulis*; 9, *Glomerella vignicaulis*.

hour-glass shape, 8–14 μ long, 2.5–3 μ wide, spores acrogenous, not catenulate (FIG. 1, 2).

Pycnidia non in maculis separatis et sparsis amphigenis in foliis sphaericis usque notate deplanatis aut fere dimidiatis atratis brunneis usque nigris membranaceis et translucidis usque nimis carbonaceis et opacis 145–260 μ diametris, aperte sub cuticula sitis et ex disco mycelii aliformis sub cuticula evolutis, ostiolis rotundatis carbonaceis paulo papilliformibus 20–25 μ diametris, sporidiis hyalinis oblongis usque paulo pyriformibus rotundatis supra et cum stipitello basilare breve sed bene definite 19–30 μ longis, 6.5–10 μ latis in basidiis simplicibus hyalinis non septatis saepe bifusiformibus 8–14 μ longis 2.5–3 μ latis acrogene nascentibus.

Occurring on lower, dead leaves and sheaths of rye (*Secale cereale* L.), near Liberty, Adams County, Ill., June 23, 1931, Acc. No. 23913 (type), and near Westville, Vermilion County, Ill., July 3, 1935, Acc. No. 25073.

The graminicolous species of *Macrophoma*² appear very similar in morphology but as indicated by specimens and descriptions, taking into account distinctions emphasized by their authors, they can be separated with a fair degree of sharpness in the following manner.

Pycnidia aggregated in crusty or stromatic masses.

Crusty masses extensive, pycnidia numerous.....*M. crustosa*

Stromata small and round, pycnidia few.....*M. erumpens*

Pycnidia separate and essentially discrete.

Pycnidia oblong in outline, on *Poa*.....*M. oblongata*

Pycnidia round to oval in outline.

Spores mostly more than 25 μ long.

Spores 15 μ or more wide, on *Zea*.....*M. Zeae*

Spores 10–12 μ wide.

Spores mostly 30–40 μ long, on *Saccharum*....*M. Sacchari*

Spores mostly 25–30 μ long, on *Koeleria*.....*M. arens*

Spores mostly less than 25 μ long.

Spores mostly more than 20 μ long.

Spore width constant, 6.5–7.5 μ , on *Phleum*.....*M. Phlei*

Spore width variable, 6.5–10 μ , on *Secale*.....*M. secalina*

Spores less than 20 μ long.

Spores slender, 2–2.5 μ wide, on *Triticum*....*M. Hennenbergii*

Spores broader, about 4 μ wide, on *Calamagrostis*

M. graminella

² *Macrophoma suspecta* Peck, upon examination of the type specimen through the courtesy of Dr. H. D. House, proves to be *Ascochyta graminicola* Sacc.

Macrophoma Rubi sp. nov.

Pycnidia scattered or tending to become gregarious or even contiguous in extensive zonately brown to purple marked stem lesions above and below nodes, black by reflected and brown and more or less translucent by transmitted light, membranous, spherical to markedly applanate, developed in and occupying decomposed cortical tissues, 135–330 μ in diameter; ostiole round, somewhat papillate, protruding through the epidermis, 10–25 μ in diameter; spores hyaline, continuous, irregularly oblong, obtuse distally, tapered basally, straight or somewhat curved, 15–25 μ long, 4.2–6.6 μ wide but chiefly 18–20 \times 4.5–5 μ .

Pycnidiis sparsis vel gregariis aut etiam contiguus in laesionibus extensis supra et infra nodos cauliis notatis zonis brunneis usque purpureis nigris luce reflexa et brunneis et plus aut minus translucidis transmissa membranaceis sphaericis usque deplanatis in telis corticis disruptis sitis 135–330 μ diametris, ostiolis rotundatis paulo papilliformibus et per epidermidem per-tudentibus 10–25 μ diametris, conidiis hyalinis continuis irregulariter oblongis obtusis ad apicem attenuatis infra rectis vel nonnihil curvis 15–25 μ longis 4.2–6.6 μ latis sed ut plurimum 18–20 \times 4.5–5 μ .

On *Rubus idaeus* L., var. *strigosus* (Michx.) Maxim. (cultivated Latham raspberry) near Barry, Pike County, Ill., August 30, 1934, Acc. No. 24802 (type).

From the comparisons I have been able to make, this fungus appears distinct from other large-spored Sphaerioidaceae reported on species of *Rubus* in America, including *Sphaeropsis rubicola* Cooke & Ellis, *Diplodia Rubi* Fries, *Sphaeropsis Rosarum* Cooke & Ellis, and *Diplodia Ruborum* (Schw.) Sacc. It, however, has spores of essentially the same size range as is given for *Macrophoma conica* Passer., reported on *Rubus Hoffmeisterianus* from Italy. The common spore size of our species is nevertheless so much smaller that a constant difference is indicated. The rarity of the Italian species in Europe and the fact that in America no *Macrophoma* appears hitherto to have been recognized on *Rubus* argue against the possibility of the two forms being members of a wide-ranging, common species.

Our species, which gains entrance at the juncture of leaf and stem, is obviously parasitic and is to be added to that already considerable group of fungi, the individuals of which are each of limited importance as a rule, but in the aggregate cause appreciable damage annually in commercial plantings.

Coniothyrium radicola sp. nov.

Mycelium (in culture) brown in mass, with gray aerial mycelium forming a deep, woolly but not felted cushion, older hyphae $5-8\ \mu$ wide, septate at intervals of 14 to $25\ \mu$, largely without dense protoplasm, younger hyphae $1.7-3.5\ \mu$ wide, septate at longer intervals; hyphae commonly conglutinated into strands. Pycnidial development meristogenous, occurring by the proliferation of cells within definite areas on conglutinated strands of 2 to several hyphae; one to several free pycnidia developed in each place; pycnidia membranous, translucent, brown, spherical to obpyriform, $90-165\ \mu$ in diameter, ostiolate, the ostiole a simple opening, not rostrate or carbonized, $20-35\ \mu$ or more in diameter. Spores tawny brown in mass, definitely brown tinted singly, spherical and $3\ \mu$ in diameter to oval to nearly oblong, $2.2-4.5\ \mu$ wide, $2.7-6.6\ \mu$ long.

Mycelio (in cultura) brunneo in massa cum hyphis aeriis griseis formantibus pulvinum altum lanatum sed non compaginatam, hyphis senescentibus $5-8\ \mu$ latis septatis ad intervalla $14-25\ \mu$ plurime sine protoplasma densa, hyphis juvenilibus $1.7-3.5\ \mu$ latis septatis ad intervalla longiora plurimum in funiculos conglutinati, pycnidiis meristogenis, separatis sed saepe caespitosis membranaceis translucidis brunneis sphaericis usque ob-pyriformibus $90-165\ \mu$ diametris, ostiolis non rostratis neque carbonaceis $20-35\ \mu$ diametris, sporidiis cervinis brunneis in massa definite brunneis tinctis singillatim sphaericis et circa $3\ \mu$ diametris usque ovalibus usque fere oblongis $2.7-6.6\ \mu$ longis $2.2-4.5\ \mu$ latis.

On *Ulmus americana* L., inhabiting the cortical parts of dying roots. Dayton, Ohio. Acc. No. 24540 (type).

CONIOTHYRIUM CARYOGENUM Rand.

Taken on *Carya alba* (L.) K. Koch., in Shelby County, Ill., about 6 miles south of Pana City, June 7, 1927 (Acc. No. 7794). This record furnishes a new host species for the fungus and constitutes a new report for Illinois. The fungus causes a white, purple bordered, oval leafspot which runs along the lateral veins. In our material, the pycnidia are erumpent epiphyllously.

Ascochyta Negundinis sp. nov.

Foliicolous; spots circular, white, diffusely and sometimes widely light brown-margined, 3-7 mm. in diameter, upper and lower surfaces similar; pycnidia scattered, situated in the mesophyll, opening chiefly epiphyllously but also rarely hypophyllously, membra-

nous and not carbonized, very light brown, spherical to greatly applanate, 99–210 μ in diameter; ostiole slightly raised and erumpent, brown, the opening roughly circular, 8–14 μ in diameter; spores hyaline, a little unequally 1-septate, the distal cell usually the larger, rarely continuous or 2- or 3-septate, oblong with bluntly rounded ends, mostly straight but frequently curved, $7.3\text{--}14.6 \times 2.5\text{--}4 \mu$, mostly $8.5\text{--}10 \times 2.9\text{--}3.6 \mu$.

Maculis in foliis rotundatis albis 3–7 mm. diametris nonnumquam cum marginibus late diffusis brunneolis in paginis superis et inferis similaribus, pycnidiis sparsis in medietate folii sitis supra raro infra pertendentibus membranaceis non carbonaceis brunneolis sphaericis usque multo deplanatis, 99–210 μ diametris, ostiolis leniter elevatis et erumpentibus, brunneis, rotundatis, 8–14 μ diametris, sporidiis hyalinis paulo inaequaliter didymis loculo supero plerumque majore raro continuis vel bis vel ter septatis oblongis rectis curvisve utrinque obtusatis $7.3\text{--}14.6 \times 2.5\text{--}4 \mu$ ut plurimum $8.5\text{--}10 \times 2.9\text{--}3.6 \mu$.

On *Acer Negundo* L., near Mt. Carroll, Carroll County, Ill., June 22, 1935, Acc. No. 25193 (type).

SEPTORIA QUERCUS Thuem.

To this species is referred a specimen on white oak (*Quercus alba* L.) collected at Hoopole, Henry County, October 8, 1934 (Acc. No. 24925). As required for the species, in comparison with what is thought to be type material in Thuemen's *Mycotheca universalis*, No. 1793, the spots are circular, measuring in our material 1.5–2 mm. in diameter, and very distinct, but lack any colored border. The pycnidia, which eventually approach acervulus-form are hypophyllous only, with very wide mouths, and 80–100 μ in diameter. Spores are definitely 1-septate, straight or somewhat curved, acute above, acuminate below, and so tend to be somewhat clavate, and measure $8.3\text{--}16.5 \times 1.5\text{--}2 \mu$. A specimen on juvenile leaves of *Quercus velutina* Lam. from the same locality on the same date (Acc. No. 24926) has spores markedly arcuate, acuminate at both ends, $8.3\text{--}21.5 \mu$ long and $1\text{--}1.5 \mu$ wide, and spots up to 4 mm. in diameter. Both specimens might, perhaps, have been assigned to *Gloeosporium septarioides* Sacc. as exemplified in Ellis and Everhart's North American Fungi No. 1629 (but not No. 2268, which is apparently an entirely different fungus), except for the definitely formed, strictly hypophyllous pycnidia. The several Septoriae, Gloeosporia, and Cylindrosporia recorded on

Quercus need careful examination and assortment, with fuller descriptions. The recorded *Septoriae* that I have seen may be ordered as follows:

Pycnidia strictly hypophyllous.

Spores 1-septate, 1–2 μ wide.....*S. Quercus*

Spores 2–4-septate, 2–4 μ wide*S. Querciti*

Pycnidia amphigenous.

Spores 50 μ or more long, 1–2 μ wide.....*S. dryina*

Spores 40 μ or less long.

Spores up to 40 μ long, 1–2 μ wide.....*S. quercina*

Spores 20–30 μ long, 3–4 μ wide.....*S. quercicola*

Chaetoseptoria gen. nov.

Pycnidia complete, spherical, separate, innate; without clypeus, subicle or stroma, ostiolate, but not rostrate, crowned with setae; spores hyaline, scolecoform. Distinguished from *Septoria* by the setose pycnidium.

Genus Sphaerioidacearum scolecosporarum cum pycnidiis perfectis separatis innatis ostiolatis et non rostratis sporulis hyalinis septatis scolecoformibus subiculo vel stromate vel clypeo carens. Ab *Septoria* circulo setarum circum ostiolum distinctum.

Chaetoseptoria Vignae sp. nov.

Pycnidia scattered, innate, becoming erumpent epiphyllously, membranous and without ostiolar darkening, 100–165 μ in diameter; ostiole round, definite, 20–30 μ in diameter, surrounded by a ring of erect, straight, brown, septate, acute setae 50–165 \times 5–9 μ . Spores hyaline, acicular, straight to arcuate, rounded distally, acute at the base, 1 to several, usually 3- or 4-septate, 18–50 \times 1.5–2.2 μ .

Pycnidiis maculas foliorum incolentibus sparsis innatis per paginam superam erumpentibus membranaceis 100–165 μ diametris, ostiolis rotundis definitis non atratis circulo setarum brunnearum septatarum rectarum erectarum 50–165 μ longarum 5–10 μ latarum coronatis, sporidiis hyalinis acicularibus rectis usque arcuatis obtusis supra acutis base semel usque pluries ut plurimum ter vel quater septatis 18–50 \times 1.5–2.2 μ .

Acc. No. 25080 (type) taken near Eldorado, Saline County, Ill., September 10, 1934. On leaves of *Vigna sinensis* Endl., in circular, yellowish, collapsed spots up to 5 mm. in diameter, distinct and with a raised, narrow, red-brown border above but indistinct below.

In its external aspect this fungus is similar to that of Tracy and Earle's incorrectly placed *Amerosporium oeconomicum*, which attacks the same host, but there appears to be no ring of dehiscence cells in the ostiole. In view of the spore form, there is no possible doubt of the correctness of classification in the Scolecosporae. The genus proposed for it here is closely allied to *Septoria* but is distinguished by the circum-ostiolar crown of setae. So far as the writer is aware, no *Septoria*-like fungus with setate pycnidia has yet been described. According to the usual wording of keys (Clements and Shear, Stevens, Engler and Prantl), Cavara's genus *Trichoseptoria* might be supposed to serve. In Cavara's³ descriptions, however, the pycnidia of *Trichoseptoria* are described as comate, and his illustrations (*l.c.*, tav. IV, figures 2 to 4 and 11) show the erumpent pycnidia to be covered with flexible hairs about equal in length to the pycnidial diameter. For convenience, then, *Septoria* may be regarded, as heretofore, as with neither hairs nor setae, *Trichoseptoria* as with hairy pycnidia, and *Chaetoseptoria* as with setose pycnidia.

Septogloeum Equiseti sp. nov.

Maculicole on stems, spots extensive longitudinally (up to 5 cm. long), often encompassing the stem, stramineous, not limited; acervuli abundant, scattered but in rows between the sclerenchyma strands, raised, oval, cinereus with dark brown to black borders, $\frac{1}{4}$ to $\frac{1}{2}$ mm. long, $\frac{1}{4}$ to $\frac{1}{2}$ mm. wide, the cuticle splitting longitudinally and irregularly at maturity; basal cushion 10–30 μ thick, a hyaline plectenchyma; spores straight to somewhat allantoid, continuous to 4-septate, hyaline, ends bluntly rounded, $20\text{--}35 \times 3\text{--}3.5 \mu$; basidia hyaline, cylindrical to clavate, $6\text{--}12 \times 2.5\text{--}3 \mu$.

Acervulis in maculis in caulibus extensis in longitudine (usque 5 cm. longis) saepe caulem circumambientibus stramineis non limitatis abundantibus sparsis sed ordinatis inter strias sclerenchymatibus elevatis ovalibus cinereis cum limbis brunneis usque nigris 250–500 μ longis et latis, cuticula scindente longitrorsum et irregulariter in maturitate pulvinulo basilare 10–30 μ denso plectenchymata hyalino sporulis rectis usque paulo allantoideis continuis usque quater septatis hyalinis utrinque rotundato-obtusis 20–35 μ longis 3–3.5 μ latis in basidiis hyalinis cylindricis usque clavatis 6–12 \times 2.5–3 μ nascentibus.

³ Cavara, Fridiano. Una malattia dei limoni (*Trichoseptoria Alpei* Cav.). Atti dell' Istituto Botanico di Pavia, II. 3: 37–44. pl. 4. 1894.

—, Ulteriore contribuzione alla micologia Lombarda. Atti dell' Istituto Botanico di Pavia, II. 3: 313–349. 1894.

On living stems of *Equisetum laevigatum* A. Br. near Sterling, Whiteside County, Ill., July 23, 1927, Acc. No. 10369 (type).

Leptostroma Querci sp. nov.

Folicle, in spots, the spots visible on both surfaces, 3–5 mm. in diameter; becoming arid, fragile, and friable, the tissue splitting radially and falling away, tan and concolorous above and below, surrounded by a narrow dark brown to black border; pycnidia amphigenous, membranous, or in age carbonaceous, innate erumpent, longer than wide, subspherical in section, 90×75 to $180 \times 150 \mu$; opening by a slit running lengthwise, the lips so formed occasionally cracked. Spores 1-celled, hyaline, long-oval to subspindle-shaped, ends subacutely rounded, $7-10 \times 2-3 \mu$.

Maculis amphigenis in foliis 3–5 mm. diametris demum aridis fragilibus et friabilibus tela scindente radiatim et dejacente brunneolis et concoloribus supra et infra angusto atro brunneo usque nigro limbo circumdatis, pycnidiis amphigenis membranaceis vel in aetate carbonaceis innatis errumpentibus longioribus quam latis subsphaericis in sectione minoribus $90 \times 75 \mu$ majoribus quorum $180 \times 150 \mu$ recludentibus rima longitrorsa labia ita formati nonnumquam fissila sporidiis non septatis hyalinis longis ovalibus usque subfusiformibus utrinque acute rotundatis $7-10 \mu$ longis $2-3 \mu$ latis.

On leaves of *Quercus imbricaria* Michx., Ramsey, Fayette County, Ill., June 7, 1927, Acc. No. 9455 (type).

SECTION OF APPLIED BOTANY AND PLANT PATHOLOGY,
ILLINOIS STATE NATURAL HISTORY SURVEY,
URBANA, ILLINOIS

EXPLANATION OF FIGURE

Fig. 1–2, *Macrophoma secalina*: 1, pycnidial section showing subcuticular, circumstolar clypeus; 2, surface view of ostiole and clypeus, illustrating radiate arrangement and aliform structure of hyphae; 3–4, *Glomerella vignicaulis*: 3, ascus with biseriate spores and apical pore; 4, three ascospores, illustrating shape and eventual septation; 5–6, *Mycosphaerella Holci*: 5, an ascospore; 6, a perithecium in section; 7–8, *Cercospora vignicaulis*: 7, a spore; 8, a stroma with conidiophore bases and two typical conidiophore tips with geniscars; 9, *Glomerella vignicaulis*: a diagrammatic reproduction of a microtome section, showing the obvious mycelial connection between its perithecia and stromata of *Cercospora vignicaulis*.

SOME HYPHOMYCETES THAT PREY ON FREE-LIVING TERRICOLOUS NEMATODES

CHARLES DRECHSLER

(WITH 18 FIGURES)

In several preliminary summaries (12, 13, 14) published a few years ago, were set forth synoptically the morphological features of 16 fungi observed to subsist by the capture of free-living nematodes infesting old agar plate cultures started from various decaying plant materials. Little attention was then given to the relationships of the different fungi to species previously described, only one among them, the widely familiar and well characterized *Arthrobotrys oligospora* Fres., whose predacious behavior had been impressively recorded by Zopf (72) nearly a half century earlier, being mentioned by name. In a subsequent paper (15), consideration of special organs developed by nematode-capturing fungi entailed identification of two other of the 16 forms; one being recognized as *Dactylaria candida* (Nees) Sacc., the other as *Dactylella ellipsospora* Grove. The remaining 13 fungi, with the exception of two species belonging in the Phycomycetes, could be referred to (16, 18, 20) only rather clumsily as members of an interrelated series of Hyphomycetes distributed in large part among the genera *Trichothecium*, *Arthrobotrys*, *Dactylella* (including *Monacrosporium*), *Dactylaria* and *Pedilospora*.

Although some of the mucedinous forms known to capture nematodes are dealt with under established binomials, usage regarding these binomials has not always been consistent. The species concerned are therefore given comparative treatment herein together with the more numerous related species of like biological habit that seem hitherto to have remained undescribed, including four discovered since the summaries were written. In addition there are appended brief accounts of two fungi, which so far have not been seen to capture or parasitize animals of any kind, yet

which in all probability represent members of the predacious series, and, perhaps, under suitable conditions may prove destructive to other organisms.

Indeed, with better adapted cultural methods and employment of materials from more varied sources, many other vermivorous Hyphomycetes will undoubtedly be brought to light. A dozen species have been cited elsewhere (18), which from their descriptions alone would seem to belong in the predacious series; the sturdier ones among them, as notably *Trichothecium inaequale* Mass. & Salm., *Monacrosporium elegans* Oud., *M. megasporum* Boed., *M. ovatum* Petch, *M. oxysporum* Sacc. & March., *Dactylella minuta* Grove, *D. minuta* var. *fusiformis* Grove, and *Dactylaria pulchra* Linder, showing in their reproductive structures such close resemblance to species known to prey on roundworms that similarity in trophic relationships is strongly suggested. The suggestion loses little plausibility through the absence of supporting testimony in the relevant literature; for in the opaque solid substrata on which the enumerated fungi were reported, microscopic animals, apparatus of capture, and all evidence of predacious activity are only too effectively concealed from view. Precisely because of such concealment *Arthrobotrys oligospora* continued for decades to be regarded as primarily a saprophytic or coprophilous plant, even among mycologists who encountered it almost daily and to whom Zopf's findings concerning it were well known. On transparent artificial substrata, however, this fungus and its vermivorous allies are readily shown to be decidedly lacking in saprophilous traits. When sizable portions of their mycelia are transferred from pure culture to maize meal agar well permeated with saprogenous bacteria but devoid of nematodes, development in any significant measure fails to take place; whereas extensive development ensues following transfer to agar both permeated with saprogenous bacteria and well infested with active nematodes. Evidently the predacious Hyphomycetes, like the Zoöpagaceae, absorb only water from their putrescent substrata, obtaining their nourishment entirely from the unfouled materials in the animals freshly killed by them.

In their choice of prey the nematode-capturing fungi show rather little discrimination between species of animals except such as may result from the physical limitations of their own predacious

apparatus. Capable of holding eelworms up to 500 or 600 μ in length, the retiary as also the constricting forms destroy promiscuously nearly all nematodes that ordinarily multiply abundantly in agar plate cultures, including besides a few semi-parasitic forms as, for example, *Aphelenchus Avenae* Bastian and *Cephalobus elongatus* de Man, many saprophilous species of *Acrobeles*, *Acrobeloides*, *Cephalobus*, *Diplogaster*, *Diploscapter*, *Plectus* and *Rhabditis*.¹ The three more delicate fungi with non-constricting rings are usually limited in their destructiveness to animals not exceeding 350 or 400 μ in length. In general, even smaller dimensions are characteristic of the prey taken by the two fungi provided only with stalked adhesive knobs; one of the two, *Dactylella asthenopaga*, often restricting its predacious activity to specimens referable to the genus *Bunonema*, which, somewhat curiously, are not frequently caught by other fungi. Except in their earlier stages of development, the more robust species of eelworms that in agar cultures soon attain lengths in excess of 600 or 700 μ , are mostly immune from capture. Yet, now and then, powerful specimens of *Dorylaimus* have been found succumbing to infection from an uprooted hyphal network that they had failed to shake off; and, occasionally, constricting rings, though torn from their stalks, have been observed inexorably bringing to an appropriate end the predatory careers of encircled specimens of *Mononchus* as much as 1 mm. in length.

The nematode-capturing Hyphomycetes are most readily isolated through removal of conidia directly from the fertile hyphae to agar plates. This is conveniently accomplished, especially in forms with tall sporophores, by bringing a small slab of agar held on a flamed platinum spatula into contact with the spores, care being taken to avoid contact with the bacterium-laden substratum. As the conidia when produced usually carry no bacteria, cultures free of all contamination are often obtained without any further operation. Except in *Dactylella bembicodes* and *Tripasporina aphanopaga* vegetative growth is moderately rapid and results in a rather dense mycelium composed of branching filaments usually

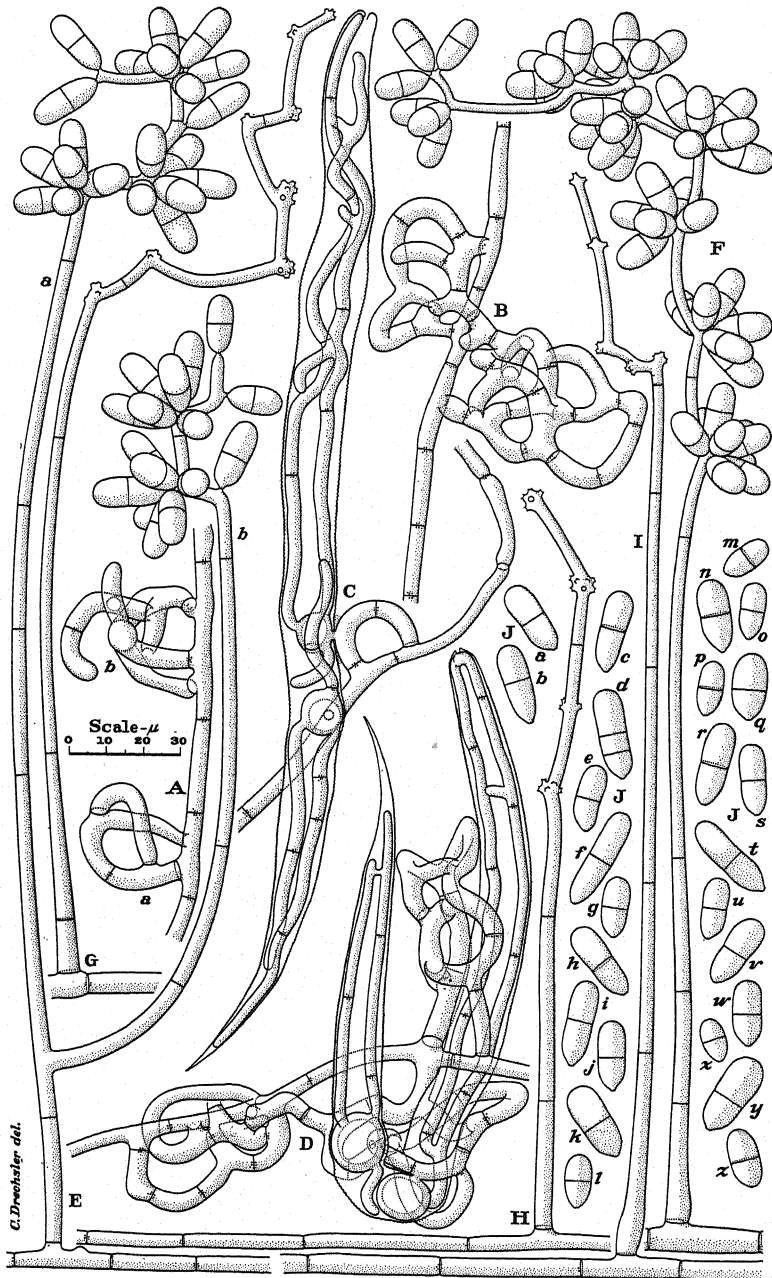
¹ For identification of nematodes I am greatly indebted to Dr. G. Steiner, Principal Nematologist in Charge, Division of Nematology, Bureau of Plant Industry, Washington, D. C.

more or less abundantly anastomosed. As in other members of the predacious series, a peculiar odor is given off in varying strength on different media. Organs of capture are regularly absent in pure culture, the production of such structures usually being indicative of invasion by mites. The retiary forms, all of which generally sporulate well on nematode-infested substrata, sporulate even better in pure culture. When protected from excessively rapid evaporation, the four polycephalous species and the two more nearly monocephalous species, *Arthrobotrys cladodes* and *Dactylaria thaumasia*, develop reproductive apparatus in spectacular luxuriance. The annulose and knobbed forms sporulate moderately in pure culture much as on wormy substrata, though a few of the species behave even more capriciously here, sometimes failing to give rise to any conidiophores at all until after exposure to strong light.

ARTHROBOTRYS SUPERBA Corda

The fungus referred to earlier (12: p. 138, lines 29-31; p. 139, fig. 2, A, B) as differing from *Arthrobotrys oligospora* in the smaller size and more nearly equal partitioning of its conidia, occurs widely in decaying vegetable materials. It has been found to develop now and then in agar plate cultures started from pieces of roots or of other underground structures decaying as a result of invasion by phycomycetous parasites. More frequently it has made its appearance on maize meal agar cultures to which, following infestation with saprophilous nematodes of such genera as *Acrobeles*, *Acrobelloides*, *Cephalobus*, *Diplogaster*, *Plectus* and *Rhabditis*, had been added pinches of leaf mold from supplies of this material gathered in deciduous woods near Beltsville, Md., Cumberland, Md., Butternut, Wis., and Madison, Wis., as well as in Arlington, Va.

A general similarity to *Arthrobotrys oligospora* at once becomes evident as the fungus extends its mycelium sparsely through a nematode-infested culture. If, on the whole, the filaments are slightly narrower than in the species described by Fresenius, the difference is certainly not pronounced. On the hyphae is borne the predacious apparatus, which consists of anastomosing bails or loops often compounded in some number to form here and there networks of variable extent (FIG. 1, A, a, b; B). Capture of prey

FIG. 1. *Arthrobotrys superba*.

can, of course, be effected by a single arch; sometimes, indeed, being accomplished merely through adhesion of the animal to the outer rim of the hyphal bail (FIG. 1, C). Instances of such capture without enmeshment are often very frequent in moist agar cultures; the bacterial slime usually covering the smooth surface here, apparently affording the animal so little hold on the substratum that it can exert no effectual leverage to pull itself away. Under drier conditions, or in the presence of bits of solid material, the struggles of the nematode are not attended with disadvantages quite as serious; so that except for the smaller larvae, adhesion in itself proves insufficient, but needs to be supplemented by enmeshment, whether in a single loop or in a more extensive anastomosed network (FIG. 1, D).

Soon after capture is effected the animal's integument is penetrated at a place median in the region of contact by a process about 2μ wide thrust out from the predacious element. On reaching the fleshy parts within, this process gives rise to a globose structure that increases in size until after an hour or two it comes to occupy a cross-section of the interior either wholly (FIG. 1, D) or in large part (FIG. 1, C). The virtual severance of the captive's body accomplished in this way, is promptly reflected in diminution of its movements. When these movements have become relatively sluggish, a number of hyphae arise from the subspherical structure and extend themselves throughout the fleshy interior, their advance being marked by conspicuous degeneration of musculature and organs, with production of very numerous globules consisting presumably of some fatty material. The contents become more and more attenuated from progressive absorption by the permeating hyphae, until finally nothing remains but the diaphanous integument collapsed about the evacuated and very inconspicuous envelopes of the assimilative filaments.

Frequently a nematode is penetrated in two (FIG. 1, C, D) or more places, and a corresponding number of globose bodies and haustorial systems are intruded to share in the appropriation of its fleshy substance. As was intimated earlier (12), there can scarcely be any doubt that the special function of the globose bodies produced in this species, as also in allied retiary and knobbed forms, is to kill the animal quickly and thus without much delay to make

it suitable for invasion by the assimilative hyphae. Certainly the rapid death of captured roundworms achieved by means of the intruded bodies, offers a marked contrast to the lingering decline of nematodes captured by the two Phycomycetes I have described elsewhere under the binomials *Stylopage hadra* (17) and *S. leiohypha* (19), neither of which develop anything that could be considered a special mortiferous structure.

On developing in agar plate cultures infested with saprophilous nematodes, and therefore in the presence of other fungi as well as of bacteria and a miscellaneous assortment of microscopic animals, the fungus gives rise to conidiophores scattered sparsely over the substratum. The individual conidiophore, arising always as an erect aerial branch from a prostrate mycelial filament, here measures mostly from 100 to 300 μ in height and from 3 to 5 μ in width at the base, whence it tapers upward to a diameter varying between 2 and 3.5 μ . At the tip it is slightly expanded and bears in capitate arrangement usually from 4 to 10 conidia, each of which on falling off leaves behind a short stumpy sterigma. Occasionally, after elongation of the conidiophore, a second head of conidia is formed (12: p. 139, fig. 2, A). Three successive conidial clusters have never been seen produced on the same sporophoric axis in nematode-infested cultures.

Much more luxuriant development of conidial apparatus ensues when the fungus is grown in pure culture on some suitable artificial medium as, for example, maize meal agar. The rapidly growing mycelium then begins to produce numerous conidiophores within a few days after planting; through repeated elongation straight-forward or at variable angles, these continue to give rise to successive conidial heads (FIG. 1, E-I), until more than a score of clusters may have been formed on a single irregularly geniculate, nodose axis. Besides, the sporophores may give off one (FIG. 1, E) or more branches, likewise bearing from one to a dozen conidia at successive nodes. Naturally the very rangy, heavily laden fertile hyphae assume a somewhat procumbent habit and thereby become confusingly entangled with one another. After about 15 days, production of conidia comes to an end, probably as a result of staling. Degeneration becomes increasingly evident, especially in widespread germination of the conidia in place, the germ tubes

anastomosing with one another, with neighboring conidia, with conidiophores, or with mycelial hyphae. Very frequently through such vegetative union the conidia of the individual heads become joined to one another and to the distal portion of the conidiophore; and are then supported approximately in their original positions in spite of disarticulation from their sterigmata. In 30 days after planting, cultures of the fungus rather characteristically show extensive evacuation of the vegetative hyphae, evacuation and general collapse of the conidiiferous filaments, germination of the conidia everywhere, accompanied often by their complete or partial evacuation, and widespread promiscuous anastomosis of germ tubes, sporiferous hyphae and vegetative filaments—giving altogether an appearance of pronounced debilitation.

Although in their continued growth and production of successive conidial heads, the sporophores of the fungus resemble those of *Arthrobotrys oligospora*, they differ markedly from the latter in their smaller diameter and generally less robust aspect. A comparison between the conidia of the two species reveals even more decisive differences. In the fungus under discussion these structures are mainly cylindrical, usually tapering only slightly toward the basal end, which is frequently little less bluntly rounded off than the distal end (FIG. 1, J, a-z). Often, indeed, the proximal half of the conidium is fully as wide as the distal half, and occasionally may even be somewhat wider. A single septum, which is sometimes placed at a slight constriction in the outer contour, and sometimes is unassociated with any external modification, divides the conidium into two approximately equal cells. While a uniseptate conidium is generally to be regarded as immature, it yet appears probable that in many instances a partition is never formed. Conidia with two cross-walls are definitely exceptional (FIG. 1, J, d). For the most part the spores vary between 12 and 23 μ in length, and between 6.5 and 9.5 μ in diameter, though specimens as much as 28 μ in length, and as much as 10 μ in diameter, have been found. The average values for these dimensions, 16.8 μ and 7.8 μ respectively, that were computed from measurements of 200 specimens taken at random from several lots of material, would seem approximately representative of the species.

In morphology of reproductive apparatus the present fungus agrees better than any other species known to me, with Corda's original description (10) of *Arthrobotrys superba*; the correspondence in production of successive heads, in general shape of the conidia, and in their division into two approximately equal cells, being especially persuasive. A tolerably satisfactory agreement with regard to spore dimensions would, moreover, seem to follow from Corda's statement that the conidia of his fungus measured "bizz 0,0006 P. Zolltheile" in length. The expression, if interpreted as referring to the old Prussian "Zoll," equivalent to 2.615 cm., would indicate a maximum conidial length of 15.69 μ . Writing only 13 years later, when presumably the linear unit concerned could hardly yet have become entirely unfamiliar, and possibly may even have still been in common use, Fresenius (23) converted Corda's expression to " $\frac{1}{55}$ – $\frac{1}{59}$ mm." or 18.2–16.9 μ .

It must be admitted, however, that departures from the description of *Arthrobotrys superba* are not wanting. In Corda's figures the conidia are shown more deeply constricted at the septum and more acutely pointed at the base than is usual in my fungus; the sterigmata at the same time being represented as acutely pointed and as spirally arranged on the separate nodes, rather than as bluntly truncate and irregularly arranged. Moreover, the conidiophores, figured consistently with branching rhizoidal systems, are set forth in the text as being provided at the base with an "ästiges, feinfaseriges, strahliges Wurzelgeflechte." The discrepancies in finer details of conidium and sterigma are perhaps to be accounted for partly in the imperfections of the microscopes used a century ago, and partly in an artistic idealism that lacked such restraint as is now usually imposed by the general use of the camera lucida. A tree-like rooting habit appears to have been attributed more often in earlier times than at present to erect sporiferous elements, possibly from a natural though frequently erroneous assumption of similarity to some robust and widely known forms like *Rhizopus nigricans* Ehrenb. that in truth reveal such a habit very clearly even on opaque substrata. If finally the clusters figured by Corda exceed those of the present fungus in number of conidia, they seem hardly less clearly to exceed also the spatial capacity of the nodes as illustrated in their denuded state—a circumstance suggest-

ing that the distinguished iconographer may have chosen here to err on the side of generosity.

In his brief but fairly unambiguous description of *Arthrobotrys oligospora*, Fresenius properly recognized the larger dimensions and unequal partitioning of the piriform conidium of his fungus as representing marked departures from the morphology ascribed to *A. superba*. Somewhat unfortunately, in view of subsequent developments, he mentioned a less profuse production of conidial heads as an important character whereby his fungus was distinguished from Corda's species; and brought this presumed diagnostic feature more prominently into relief in his choice of a name that anyone who has seen the fungus to which it was applied growing in pure culture on a favorable substratum, cannot fail to consider a singularly unhappy one. In spite of these differences, actual and supposed, Fresenius confessed to having harbored misgivings that his fungus might after all be identical with *A. superba*, adding with a hint of suspicion, that in such event it would need to be assumed that Corda's description had in excessive measure sacrificed accuracy to artistic effect.

Coemans (8) after studying some material of *Arthrobotrys* concluded that Corda had been inexact in representing the conidia of his fungus as consisting of two equal cells. He recognized *A. oligospora* as merely a somewhat depauperate form of *A. superba* bearing not more than three verticillate clusters, with few conidia in a cluster. It remains uncertain with which or with how many species of *Arthrobotrys* this investigator may have been dealing. His reference to a variation wherein 2-celled, somewhat elongated, small conidia (12 to 15 μ in length) originated from mycelial filaments, may well have been based on some admixture of material with anastomosing germ tubes, referable either to the species under consideration or to *A. cladodes*; though the possibility that very small spores of one of the larger species may have been concerned, is not to be excluded. Rather curiously, Coemans figured a group of conidia having their two component cells no less equal to one another than those shown in the illustrations of Corda denounced by him. Nevertheless, his strong approval of Fresenius' illustrations indicates that probably for the most part he was dealing with the species described by the German mycologist; the

range in spore lengths reported by him, 30 to 40 μ , corroborating in a puzzling manner the decidedly high value, $\frac{1}{28}$ mm., or 35.7 μ , assigned to this dimension in the original description of *A. oligospora*. Coemans' larger illustrations of "spores didymes de l'*Arthrobotrys superba*," though not noticeably impaired by any artistic virtues, show in each of the three specimens figured such deep constriction at the septum, which is placed slightly below the middle, that identification with one or another of the predacious fungi herein discussed is hardly to be attempted.

The nomenclatorial confusion of *Arthrobotrys superba* with *A. oligospora* thus initiated, was later promoted effectively through the meritorious researches of Matruchot (47). This author apparently recognized the number of successive conidial clusters as the sole difference between the two species as they occur on natural substrata. He succeeded several times in isolating typical *A. oligospora*, and observed that the fungus which on the original substratum had normally shown two or three spore clusters developed as many as 16 superimposed heads when grown in pure culture on moist slices of carrot. Thus misled by the similarity in asexual reproductive development of the two species, and apparently having neither seen plants with generally smaller conidia divided into approximately equal segments, nor considered the likelihood of such plants being existant, he reduced *A. oligospora* to the status of a cultural form of the earlier described *A. superba*. While this disposition conserved Corda's binomial, it transferred to his species the morphological characterization of an entirely separate congeneric fungus. The application of *A. superba* inaugurated by Coemans and adopted by Matruchot was given wider currency on being incorporated in the works of Saccardo (61), Massee and Salmon (46) and Lindau (38); and has evidently in large part at least governed such scattered usage as has subsequently been accorded to the binomial. Thus, in the absence of morphological comment, it appears probable that citations of *A. superba* found in such floristic contributions as those of Eisenach (21), Smith and Rea (66), Rea (57), Schmidt (63), and Girzitska (25) were based on specimens of *A. oligospora*. Lind's (37) separate enumeration of *A. superba* and *A. oligospora* furnishes evidence that this author regarded the two species as being

distinct, without however indicating on what grounds the distinction was acknowledged. On the other hand, Mahju's (43) description of *A. superba*, based on material from rabbit dung in India, shows such close agreement in morphological detail with the nematode-capturing fungi to which I am applying Corda's binomial that its identity with the latter appears altogether probable. The approximately equal partitioning of the conidia and the slight inflation of the sporiferous nodes shown in Berlese's (3) figures of *A. arthrobotryoides* (Berl.) Lindau (= *Trichothecium roseum* var. *arthrobotryoides* Berl.), together with the dimensions, $20-22 \times 9-10 \mu$, attributed to the conidia, suggest the possibility that the Italian author likewise was dealing with Corda's fungus.

Chlamydospores of the type formed by *Arthrobotrys oligospora*, *A. conoides*, *A. musiformis* and *Dactylaria thaumasias* have never been observed either in pure or in nematode-infested cultures of *A. superba*.

Shortly after the present studies were begun, there were found developing in a wormy agar plate culture of *Arthrobotrys superba* about a score of flesh-colored disciform apothecia mostly between .5 and .8 mm. in diameter. Viewed from above these apothecia showed individually a central, perceptibly upcurved hymenial region, and surrounding it a slightly prominent circular border (FIG. 18, R, a). Except for its somewhat slender central stalk, each fruiting body rested with its under side flush on the substratum. In sections of the hymenium the most nearly mature of the cylindrical asci, measuring 29 to 32 μ in length and 3.1 to 3.4 μ in width, revealed 8 colorless hyaline tear-shaped ascospores about 5 μ long and 1.3 μ wide, the widened ends of the upper spores being directed toward the apex, those of the lower spores toward the base (FIG. 18, R, b-d).

As most of the apothecia were slow in maturing, the culture was bathed in water for a time in the hope that accumulated staling products might thereby be partially removed. This treatment, which had previously been found beneficial for the maturation of some much hardier Sphaeriaceae, unfortunately resulted in a thoroughgoing degeneration of every one of the apothecia, making it then impossible to determine the presence or absence of a pleo-

morphic connection with the predacious conidial form. The disco-mycete has not been seen again, in spite of several attempts to recover it by employing various substrata, and by planting different strains of *Arthrobotrys superba* together on the same plate culture. At first thought the small size of the ascospores would seem to preclude definitely any pleomorphic connection with a fungus dependent for its nourishment on capture of nematodes, since such capture requires in the very beginning a substantial outlay of material for the development of predacious apparatus that needs to be sturdy as well as of some extent. However, the similarity in shape of the ascospores to the endogenous spores of *Protascus subuliformis* Dang. (11) suggests that possibly the sexual spores of the predacious Hyphomycetes might begin development in the manner usual among parasites, that is, by adhering to the animal, penetrating the integument and extending a mycelium through the fleshy interior.

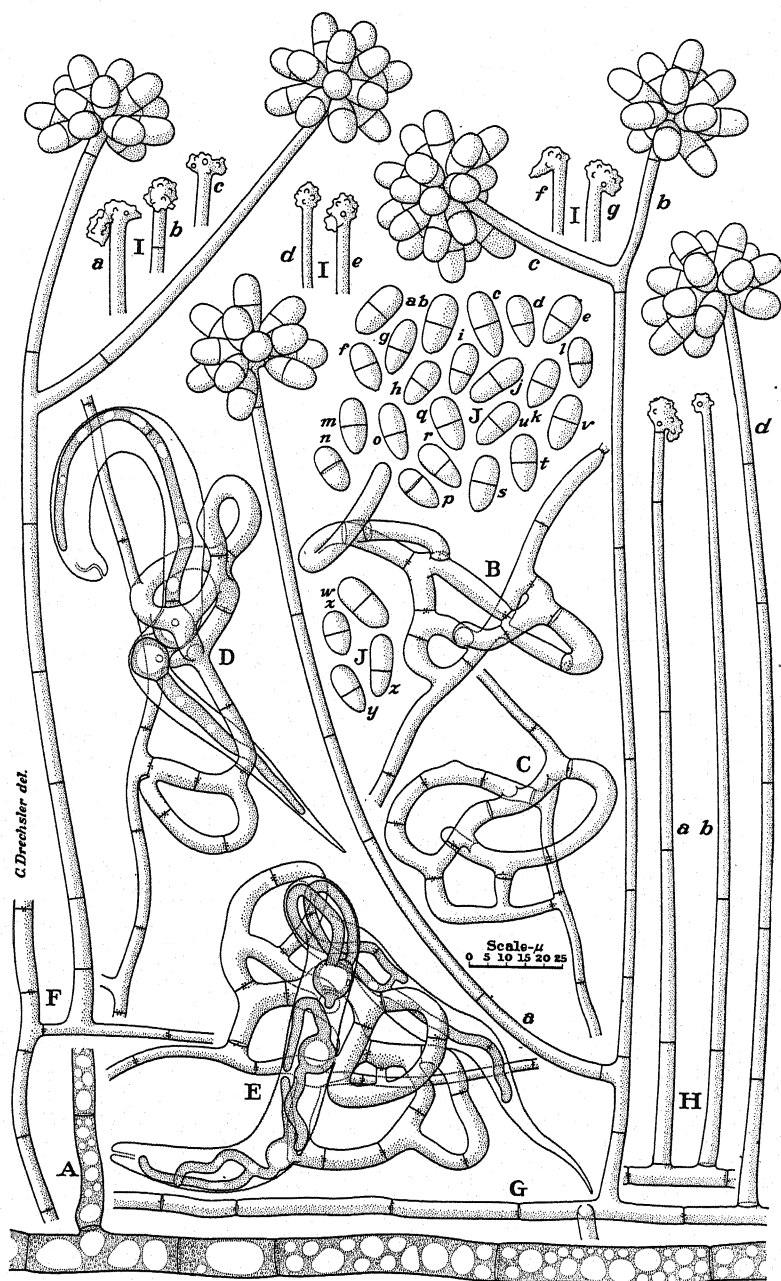
ARTHROBOTRYS CLADODES

A fungus so similar to *Arthrobotrys superba* that I first mistook it for that species, was repeatedly obtained in nematode-infested agar plate cultures to which pinches of leaf mold from deciduous woods in Virginia and Maryland had been added. In its vegetative stage there is little to distinguish it from Corda's species, or for that matter, from *A. oligospora* and *A. conoides*; a general family resemblance to those congeneric forms being evident not only in the undifferentiated mycelial hyphae and in the greatly enlarged storage filaments often developing tardily (FIG. 2, A), but also in the predacious apparatus. For this apparatus consists likewise of fused hyphal bails or loops that at the beginning are formed singly here and there on the mycelial filaments, but usually soon become compounded into more or less extensive anastomosing reticular systems (FIG. 2, B, C). Nematodes are captured often through mere adhesion to the outer surface of these specialized structures (FIG. 2, E), or through adhesion combined with physical enmeshment (FIG. 2, D).

To extend the resemblance, the sparsely scattered conidiophores arising from the substratum in nematode-infected cultures present much the same appearance as the usually monocephalous conidio-

phores produced by *Arthrobotrys superba* under similar conditions. Unlike that species, however, when the fungus is brought into pure culture on a favorable medium, as, for example, maize meal agar, it is slow in giving rise to conidiophores. Often no fertile hyphae are formed until two or three weeks after the culture was planted—at a time, therefore, when in contemporary cultures of *A. superba* conidial production has usually come to an end, and degeneration is well under way. The acme of reproductive development is ordinarily not reached until four weeks after planting; examination of the conidiophorous turf under low magnification then revealing an innumerable array of handsome spore clusters, all in prime condition like the hyphae supporting them, and offering accordingly a very marked contrast to the advanced debilitation evident in cultures of *A. superba* started at the same time.

Axial elongation of the conidiophores with development of successive spore clusters takes place only rather infrequently; increase in number of heads being made possible, instead, through the production of one (FIG. 2, *F*) or more (FIG. 2, *G*, *a*, *c*) branches from the primary axis. Each of the branches, after giving rise to a terminal cluster of conidia, may in turn supply a number of fertile elements. Lateral branching, combined often with crowded arrangement of the conidiophores on the parent filament (FIG. 2, *F*, *H*), thus accomplishes here, in part at least, the purpose accomplished in *Arthrobotrys superba* through repeated elongation. Besides, the individual heads contain a larger number of spores than are ordinarily found at separate nodes in Corda's species; the considerably greater spatial requirements being provided for through marked inflation of the sporiferous tips (FIG. 2, *H*, *I*, *a-g*), which in the more extreme instances often come to appear as lobulate or coralloid enlargements (FIG. 2, *H*, *a*; *I*, *a*, *b*, *e*). A denser capitate arrangement is made possible by noticeable tapering in the proximal portion of many conidia (FIG. 2, *J*, *a-z*). If the two cells composing the more tapering specimens (FIG. 2, *J*, *d*, *e*, *h*, *i*, *o*, *y*, *z*) are often perceptibly unequal, the conidia on the whole yet show both in shape and partitioning as also in size much more similarity to *A. superba* than to *A. oligospora*. Variations in the conidial dimensions would seem somewhat less pronounced than in some other nematode-capturing Hyphomycetes. The 200 spore meas-

FIG. 2. *Arthrobotrys cladodes*.

urements from which were obtained the relevant dimensional ranges and computed averages submitted in the diagnosis—measurements made on specimens taken at random in equal numbers from four different strains growing in pure culture on maize meal agar in Petri dishes—gave a distribution of values for length expressed to the nearest micron as follows: 11 μ , 2; 12 μ , 3; 13 μ , 20; 14 μ , 55; 15 μ , 71; 16 μ , 42; 17 μ , 6; 18 μ , 1; and a distribution of values for width as follows: 6 μ , 2; 7 μ , 120; 8 μ , 77; 9 μ , 1.

As has been intimated, the fungus, even when producing conidia very profusely, only occasionally shows a succession of clusters on a repeatedly elongated conidiophore. Its eligibility for inclusion in *Arthrobotrys* might therefore be questioned as Corda in his definition of the genus specified nodulose "flocci" presumably of the type found in *A. superba*. The requirement thus introduced was retained in the generic diagnosis published by Saccardo, according to whose system the corresponding monocephalous forms would need to be referred to *Cephalothecium*. In defining the genus *Arthrobotrys*, Lindau likewise mentioned the presence of nodose swellings with conidium-bearing protuberances among the characteristics pertaining to the conidiophore. Except for the additional attribute of repeated elongation and repeated sporulation, he regarded *Arthrobotrys* as virtually identical with *Trichothecium*, to which genus he assimilated *Cephalothecium* and with it presumably all monocephalous fungi like the one under consideration.

The misunderstanding underlying the slightly variant dispositions favored by Saccardo and by Lindau will receive attention more appropriately in the discussion of *Arthrobotrys oligospora*. It can hardly be a matter of astonishment if these distinguished compilers, perhaps neither of whom had ever had occasion to become very familiar with any species of either *Arthrobotrys* or *Trichothecium*, should have been somewhat misled by the flow of wrong opinion issuing persistently from investigators who had studied material of one genus and held it representative of both.

The predacious fungus illustrated in figure 2 is beyond any doubt closely related to *Arthrobotrys superba*; and no less certainly is wholly lacking in intimate relationship to *Trichothecium roseum* Link (= *Cephalothecium roseum* Corda). It is assigned, there-

fore, to the genus typified by the former species, in the hope that the slight adjustment in prevailing concept will commend itself to students of the group. A term having reference to the branching habit of its conidiophores is proposed as specific name.

***Arthrobotrys cladodes* sp. nov.**

Mycelium effusum; hyphis hyalinis septatis, plerumque $2-7\mu$ crassis, subinde usque 11μ crassis protoplasmatis confertim repletis, laqueos tenaces arcuatos vel circulares in reticula saepe conjunctos evolventibus; his laqueis vermiculos nematodeos illaqueantibus, deinde tum integumentum perforantibus, tuber mortiferum intrudentibus, hyphas intus evolventibus quae carnem exhaustiunt. Hyphae fertiles hyalinae, erectae, septatae, ramosae, $200-400\mu$ altae, basi $4-7\mu$ crassae, sursum paulo fastigatae, subter apicem $2.5-4\mu$ crassae, apice verrucosae irregulariter dilatatae modo globosae modo coralloideae $5-30$ conidia in capitulum confertum aggregata ferentes. Conidia hyalina, ellipsoidea vel elongato-obovoidea, ad septum subinde paulo contracta, $11-18\mu$ (saepe circa 14.7μ) longa, $6.2-8.8\mu$ (saepe circa 7.3μ) lata, loculis duobus inter se nunc aequalibus nunc inaequalibus, loculo superiore interdum majore rarius minore quam loculo inferiore. Chlamydosporae ignotae.

Vermiculos nematodeos diversos vulgo usque .5 mm. longos laqueans consumensque habitat in humo silvestri, in Arlington, Virginia, atque prope Beltsville et Cumberland, Maryland.

Mycelium spreading; vegetative hyphae hyaline, septate, except for occasional storage filaments that are densely filled with protoplasm and up to 11μ wide measuring mostly 2 to 7μ in diameter, often especially in the presence of nematodes giving rise to hyphal bails and loops, which, though at first discrete, are later frequently compounded into more or less extensive networks; the bails and networks capturing nematodes through adhesion and entanglement, perforating the integument of each animal and intruding one or more globose mortiferous excrescences from which are extended assimilative hyphae to appropriate the fleshy contents. Conidiophores hyaline, erect, septate, frequently more or less branched, 200 to 400μ high, 4 to 7μ wide at the base, tapering gradually upward to a width of 2.5 to 4μ below the irregularly expanded, globose or somewhat coralloid tip whereon are borne 5 to 30 conidia in usually dense capitate arrangement. Conidia hyaline, ellipsoid or elongate obovoid, mostly 11 to 18μ (average 14.7μ) long, 6.2 to 8.8μ (average 7.3μ) wide, uniseptate, the upper cell often approximately of the same size as the lower or slightly larger, but occasionally somewhat smaller. Chlamydospores not known.

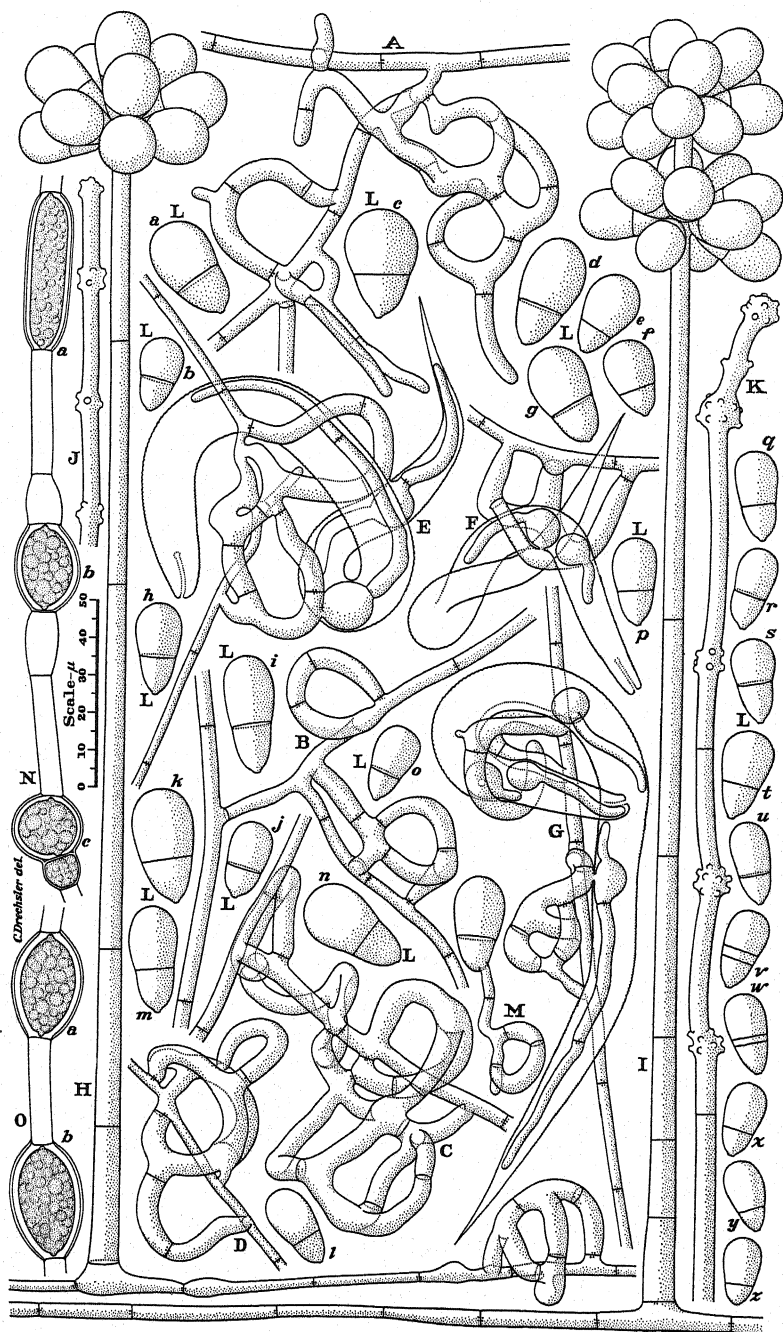
Capturing and consuming nematodes commonly measuring up to .5 mm. in length and mostly referable to the genera *Acrobeles*,

Acrobeloides, *Cephalobus*, *Diplogaster*, *Diploscapter*, *Plectus* and *Rhabditis*, it occurs in leaf mold near Beltsville, Md., near Cumberland, Md., and in Arlington, Va.

ARTHROBOTRYS OLIGOSPORA Fres.

Of all predacious fungi *Arthrobotrys oligospora* is undoubtedly by far the most widely known among mycologists. Its ready appearance on a wide variety of decaying vegetable materials as well as on the dung of many wild and domestic animals, following incubation in a damp chamber, has made it a familiar object to the numerous investigators who have devoted attention to the saprophytic, and often more particularly to the coprophilous flora of their respective localities. After addition of small masses of decomposing refuse to nematode-infested agar plate cultures, it makes its appearance not only more frequently than any other of the related predacious forms, but perhaps in larger quantity than all the other predacious forms taken together. Indeed, its prompt and rapid development in such cultures, by bringing about an early and usually tremendous reduction in the supply of eelworms available for slower-growing forms, often operates in an annoying manner to conceal the true content of nematode-destroying microorganisms present in materials under study.

The vegetative filaments of the fungus show the disposition usual for members of the series: being arranged somewhat radially in a fairly compact mycelium when developing in pure culture on agar media; but in nematode-infested cultures only sparsely permeating the substratum and bearing predacious apparatus in seemingly haphazard distribution. This apparatus, consisting of hyphal bails that are first discrete but later usually are compounded into more or less extensive networks (FIG. 3, *A-D*), closely resembles that produced under similar conditions by *Arthrobotrys superba* and *A. cladodes*, except that in the present species the bail-like elements often appear a little rangier and the meshes correspondingly a little wider. Woronin (71) first gave a descriptive account of the hyphal bails and networks, without, however, offering any explanation as to their use. Their special function in the capture of nematodes was later capably set forth by Zopf in the classical

FIG. 3. *Arthrobotrys oligospora*.

memoir wherein also, though less plausibly, was given an intimation of similar utility in the "conidia" of his *Monosporidium repens*. Despite the unescapable suggestion in the operation of the supposed conidia of some other mode of prehension, the efficacy of the predacious organs formed by *A. oligospora* was imputed entirely to physical entanglement. Actually, of course, in this as in other retiary species, the secretion of an adhesive substance is exceedingly important in the capture of nematodes. Soon after capture is effected the animal's integument is perforated, and one or more mortiferous bodies are intruded, from which assimilative hyphae are extended through the fleshy interior (FIG. 3, E, F, G).

Though Zopf included an adequate account of the remarkable biological relationships of *Arthrobotrys oligospora* in his general treatise on fungi (73), his discoveries evoked surprisingly little response at the time. Matruchot somewhat casually referred to Zopf's fungus as a strain of *A. oligospora* living parasitically on a species of nematode, without betraying any hint of recognition that the parasitism in question was anything but commonplace. Possibly, indeed, the true distinctiveness of the biological relationship represented here could not be fully appreciated until an analogous instance was brought to light in the discovery by Sommerstorff more than two decades later of his *Zoöphagus insidians*, an aquatic phycomycete subsisting through the capture of rotifers. Both in the excellent original descriptive account (67) of this fungus and in a shorter interpretative communication (68), Sommerstorff appropriately recalled *A. oligospora*, as did also Mirande (48) and Gicklhorn (24) in later publications on *Z. insidians*. A continuing interest in carnivorous and predacious fungi subsequently inspired a review-article by Kostka (36) wherein Zopf's observations on *A. oligospora* were rather fully set forth, together with relevant speculations that appear of moment more particularly from a discerning prediction that further research might show adhesive material operative in the capture of prey. Brief statements at second hand, concerning the predacious action of the same fungus were given in recent years by Goffart (26) and Stehli (69). In the meantime a serious lack of corroborative testimony had been corrected when from observations at first hand Rahm (56) noted that moss-inhabiting eelworms belonging to species of *Tylenchus*

and of *Mononchus* became abundantly entangled in hyphal bails of the fungus; entanglement being followed by invasion of the captives, fatty degeneration of their soft structures, and death. Additional records of *A. oligospora* in predacious relationship have since been supplied by Sherbakoff (64) and Linford (40). Of kindred interest is Korab's (35) inclusion of the fungus among the parasites destructive to cysts of the sugar beet nematode, *Heterodera Schachtii* Schm., in Russia.

After its predacious apparatus has for some time been operative in nematode-infested maize meal agar-plate cultures, *Arthrobotrys oligospora* gives rise to sporophores that in the aggregate often become visible to the naked eye as a sparse downy turf. Individually these are sturdy structures, often divided by 3 to 8 cross-walls, measuring mostly 7 to 10 μ at the base and tapering gradually upward to a diameter of 4 to 6.5 μ below the first head of conidia, which is commonly formed at a height of 350 to 450 μ , though instances of heads formed at lesser heights are to be found (FIG. 3, H, I). Development may cease with the production of one head, or through repeated elongation of the axis several more heads may be added successively; conidiophores with four or a greater number of clusters being, however, not frequent in such material. The conidia thus produced (FIG. 3, L, a, c, d, g, i, k, m, n) are plump, obovoid bodies, mostly 22 to 32 μ long and 12 to 20 μ wide, measurements of 100 specimens taken at random giving values of 26.6 μ and 15.8 μ for average length and average width respectively.

In pure culture on suitable media, as, for example, maize meal agar, sporulation is much more profuse. If care is taken to reduce normal evaporation the individual conidiophores continue to develop successive conidial heads, so that in six weeks fertile hyphae weighted down horizontally with 20 to 30 spore clusters are piled on one another to form a loosely matted aerial tangle. Usually the conidiophores here are somewhat less stout than when arising from wormy substrata, measuring mostly 6 to 8 μ in width at the base, and diminishing to a width of 4 to 5.5 μ in the sporiferous portion (FIG. 3, J, K). The conidia, too, are smaller than those produced on nematode-infested media, measurements of 100 specimens taken at random showing a range in length of from 18 to 30 μ , and a range in width of from 10 to 15 μ , and yielding com-

puted averages of $23.3\ \mu$ and $12.6\ \mu$ for these dimensions respectively. When agar plate cultures are exposed in a manner to permit free evaporation, the increasingly dry conditions that then come about are reflected in progressive reduction in size of the conidia produced as sporulation gradually comes to an end.

The differences in reproductive habit and conidial dimensions associated with development on wormy agar media as compared with reproductive habit and dimensions associated with development in pure culture, represent approximately the morphological differences indicated as separating *Arthrobotrys superba* var. *oligospora* from typical *A. superba* by those authors who identified the present fungus with Corda's species, and accordingly subsumed material with few heads as a variety thereof. Among these authors, Saccardo (61) indicated for the conidia of *A. superba* a length of 20 to $26\ \mu$, and a width of 12 to $15\ \mu$; whereas the corresponding dimensions of *A. superba* var. *oligospora* were given as being 23 to $27\ \mu$ and 14 to $17\ \mu$ respectively. Again, Lindau indicated for the conidia of *A. superba* a length of 20 to $26\ \mu$ and a width of 13 to $15\ \mu$; for those of *A. superba* var. *oligospora* a length of 23 to $28\ \mu$ and a width of 14 to $19\ \mu$. It is not surprising that development on wormy agar should be much the same as on dung or on decaying plant remains, since on any of these substrata the fungus must live exclusively on the nematodes infesting them—a food supply often very abundant for a time but locally subject to serious reduction, or even to virtual depletion, after a relatively short period of exploitation. In any case, if the values given by Loew (42) for conidial dimensions, 25 to $30\ \mu$ for length and 14 to $18\ \mu$ for width, or those given by Oudemans (52), $28\ \mu$ for length and 16 to $19\ \mu$ for width, or those given by Grove (29), $30\ \mu$ for length and $15\ \mu$ for width, appear considerably larger than the corresponding values, $20\ \mu$ and $15\ \mu$ respectively, mentioned by Matruchot, an explanation for the difference may be found in the circumstance that Loew and Oudemans like Grove used natural substrata, whereas Matruchot studied the fungus in pure culture on sliced carrots. On the other hand, the value for length of conidium, $\frac{1}{28}$ mm. or $35.7\ \mu$, given by Fresenius, and also the range for this dimension, 30 to $40\ \mu$, submitted by Coemans, would seem

somewhat higher than might be expected even in material from natural substrata such as these writers studied.

From *Arthrobotrys superba* and *A. cladodes*, the two species previously discussed, *A. oligospora* is distinguished not alone by generally greater conidial dimensions, but also, and perhaps more especially by the inequality in size of the two segments into which its conidium is typically divided. The cross-wall delimiting the segments is placed at a distance from the base varying mostly from one-third to two-fifths of the length of the spore. As the distal cell is therefore longer than the basal cell, besides being wider because of the obovoid shape of the spore, its volume may well be 1.5 to 3 or occasionally even 4 times that of the proximal segment. In Massee's (45) figures of his *A. rosea* similar proportions between basal and distal cells are revealed. Indeed, except for the acutely pointed shape of the "minute spicules arranged in a spiral, to which the conidia are attached," Massee's description fits *A. oligospora* so well that few would disagree with Matruchot in considering *A. rosea* identical with the older species of Fresenius. Apparently the description was written without any knowledge of Fresenius' publication, yet is deserving of commendation in distinguishing the fungus under consideration from *A. superba* on the proper ground that the latter has "oblong conidia divided into equal parts by the septum." Possibly another and much more questionable synonymy might be inferred from Preuss' description (54) of the spores of his *A. recta* as being obovoid—the remainder of the diagnosis, which antedates that of Fresenius, being, however, so lacking in specific characterization that positive reference to any particular fungus seems definitely out of the question.

A troublesome misconception, referred to previously, concerning the relationship of the genus *Arthrobotrys* to *Trichothecium* (including *Cephalothecium*) has long persisted through an obstinate confusion of *A. oligospora* with *T. roseum* Link. Rather curiously the confusion was initiated after the morphological characteristics distinguishing the two genera had been adequately set forth. After Corda in 1839 had described the arrangement of conidia on the conidiophore in *A. superba* very graphically and with regard to the more essential points, quite correctly, Fresenius made known a similar arrangement and development in *A. oligospora*.

Hoffmann (32) in 1854 described sporulation in *T. roseum* to proceed, following delimitation of a first terminal spore, by production of lateral outgrowths from successively lower portions of the fertile hypha, each outgrowth and associated axial portion being in turn converted into a conidium. The next year Bail (1) confirmed Hoffmann's description, characterizing the arrangement of the spores in *T. roseum* as an alternately spicate one which on casual examination simulates a verticillate arrangement. Then in 1866 Münter (49) published an account of a Hyphomycete that gave rise to heads of conidia approximately after the manner described by Hoffmann; but apparently not being aware of either Hoffmann's or Bail's contribution, he insisted on identifying his fungus with *A. oligospora*. The morphological departures from the description of the latter species Münter held attributable to faulty observation on the part of Fresenius! Corroboration of Münter's findings soon appeared in a paper by Loew (41), which represented spore development like that set forth by Hoffmann taking place in a fungus recognized as entirely similar to Münter's, and likewise referred, though with expressed misgivings, to *A. oligospora*. De Bary (2) thereupon pointed out that the studies reported by Münter and Loew had not been carried out on *A. oligospora*, nor indeed, on any species of *Arthrobotrys* at all, but on the widely distributed *T. roseum*. With this altogether sufficient explanation Karsten (34) promptly took issue, asserting that the fungus growing out of material received from Münter showed under appropriate cultivation a succession of spore clusters and development of spore pedicels just as had been described by Fresenius. He concluded therefore that Münter's fungus was identical with *A. oligospora*; which species, however, he considered as representing not a member of the genus *Arthrobotrys*, but a variety of *T. roseum*. In 1870 Woronin again presented De Bary's arguments to the effect that Loew's as well as Münter's conclusions were wrong, being based on *T. roseum* rather than on true *A. oligospora*. Nevertheless Harz (30) a year later came forward with a view not dissimilar from Karsten's, holding that Fresenius had erroneously assigned a luxuriant form of *T. roseum* with repeated spore clusters to *Arthrobotrys*; and accordingly cited *T.*

roseum together with *A. oligospora* and *A. superba* β *oligospora* in an impressively copious synonymy.

It remains to Loew's credit that after his earlier contribution had thus been given confirmation of a sort, he (42) emended his position as a result of studies on material of true *Arthrobotrys oligospora* which he had in the meantime acquired. He now quite understandably agreed with the views of De Bary and of Woronin bearing on the identity of the fungus previously studied by himself and Münter, and on the separateness of that fungus from *A. oligospora*. The repeated conidial heads and the sterigmata reported by Karsten he explained through the presumption that this author had dealt with a mixture of *A. oligospora* and *T. roseum*.

Constantin (9) in 1888 confirmed from personal observation the distinction drawn by De Bary, by Woronin and by Loew between *Arthrobotrys oligospora* and *Trichothecium roseum*. Yet even during the same year the two genera typified in these species were again confused when Berlese (3) described under the name *T. roseum* var. *arthrobotryoides* a fungus that obviously was a true *Arthrobotrys* whether referable to *A. oligospora* as Matruchot considered certain, or to *A. superba* as appears to me about equally possible. Though Matruchot's memoir, which appeared four years later and was based on extensive comparative studies wherein pure cultures were employed, may have been mischievous in erroneously assimilating *A. oligospora* to *A. superba*, it nevertheless should have laid any lingering doubt concerning the wide difference in morphology of conidial apparatus between the former species and *T. roseum*. Still, two decades later, Grove (29) mentioned *A. oligospora* and *T. roseum* in a list of probable synonyms that included notably also *T. obovatum* Sacc. and *A. superba*; holding that nothing but cultures under diverse conditions could decide whether the names cited apply to different species or to varying states of one species. In 1918 Elliott (22), apparently not cognizant of similar earlier studies, described anew from observations at first hand the course of conidial development in *T. roseum*. Again, in more recent times, Reinhardt (58), though fully informed of earlier contributions on the subject, considered it far from superfluous to submit an illustrated account of spore forma-

tion in the same fungus, contrasting its successive basipetal course with the truly capitate development in *A. oligospora*.

In view more particularly of the suggestion made by Grove, I took occasion to grow in pure culture on several artificial media two strains of *T. roseum* originally isolated from apple fruits affected with pink rot. The cultures prepared in this way showed only the most superficial outward similarity to parallel cultures of *Arthrobotrys oligospora*. Microscopic inspection revealed the characteristic development of conidia repeatedly described in the literature. Conidial apparatus and vegetative mycelium were equally lacking in the intimate family resemblance to *A. oligospora* that unmistakably comes to light in members of the predacious series, often despite pronounced differences in reproductive habit. When large pieces cut from agar plate cultures of *T. roseum* were placed on agar cultures abundantly infested with nematodes, *Amoebae* and shelled rhizopods, no predacious qualities of any kind were ever manifested. In fine, a clear impression was left that *T. roseum* is not only distinct from *A. oligospora* as a species, but is alien to the series, and therefore definitely more remote than are, for example, the fungi I described earlier as *Pedilospora dactylopaga* (16) and *Dactylella passalopaga* (20). And assuredly, Vanha's (70) citation of *Trichothecium* as a fungus capturing nematodes in the soil must have been based on some species other than *T. roseum*.

Chlamydospores, first reported in the fungus, though apparently in somewhat immature condition, by Woronin, and later fully described by Zopf (72), regularly make their appearance in old cultures, whether these be pure or infested with nematodes. When mature they have usually a distinctly yellow color. They show considerable variety in shape, some being mostly cylindrical (FIG. 3, N, a), others subspherical (FIG. 3, N, c) and still others ellipsoid (FIG. 3, N, b; O, a, b). The enveloping wall usually shows two layers, a thin outer layer presumably consisting of the original hyphal membrane, and rather closely adnate to it, a thick inner layer marked with a deep central pit at each of the ends.

ARTHROBOTRYS CONOIDES

Of the several congeneric forms dealt with herein, the one morphologically most similar to *Arthrobotrys oligospora* was referred to and figured in an earlier summary (12: p. 138, lines 31-34; p. 139, fig. 3, A-C) as bearing longer conidia with characteristically tapering basal cells. It has been found especially frequently in decaying plant refuse from greenhouses, as also in débris of similar nature accumulating in meager quantity under potted house plants. Though apparently of somewhat less abundant occurrence out of doors, it has yet developed in many nematode-infested plate cultures to which had been added pieces of decaying roots of herbaceous field plants or pinches of leaf mold from deciduous woods.

The mycelium of the fungus has much the same appearance as that of *Arthrobotrys oligospora*. In nematode-infested agar plate cultures the vegetative filaments are sparsely extended to produce here and there hyphal bails that often become compounded into more or less rangy networks (FIG. 4, A, B). Under moist conditions the animals are held, sometimes in enormous numbers, largely through adhesion to the anastomosing elements (FIG. 4, C); entanglement becoming necessary to effect capture, at least of the larger and more vigorous prey, under drier conditions. (FIG. 4, D). The killing of the eelworms by intrusion of globose structures, and appropriation of their fleshy substance by assimilative hyphae arising from the globose bodies, ensues as in the forms already discussed.

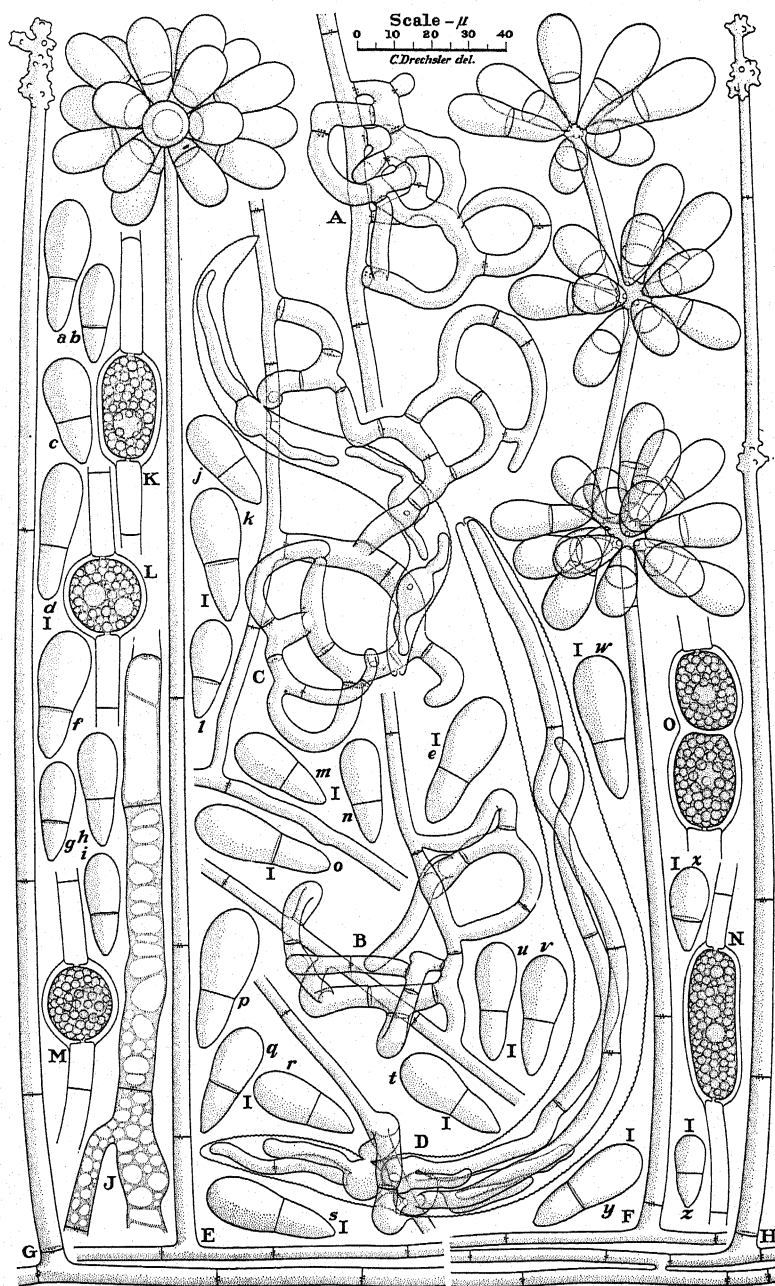
Tall conidiophores are produced on wormy agar media, occasionally in such numbers as to become visible to the naked eye as a fine downy growth. They usually conclude their development with the production of a single terminal conidial head, often containing 20 to 30 spores in compact arrangement (FIG. 4, E). In pure culture on maize meal agar, with evaporation reduced to prevent early drying out of the substratum, the conidiophores continue development by repeated elongation and successive production of 5 to 10 additional spore clusters. The individual clusters in series thus produced ordinarily consist of fewer conidia than the single heads on fertile hyphae arising from wormy substrata; the capitate

arrangement being, of course, correspondingly looser (FIG. 4, *F*). Denuded conidiophores show modification of the sporiferous parts, whether terminal or intercalary, commensurate with the number of spores that had been formed thereon (FIG. 4, *G*, *H*).

Arrangement of the conidia in compact heads is facilitated by their distinctive conformation. Comparison of the values pertaining to conidial dimensions in the diagnosis below, which were derived from measurements of 200 specimens taken at random, with the homologous values for *Arthrobotrys oligospora*, shows considerably greater length and appreciably lesser width in the conidia of the present species (FIG. 4, *I*, *a-z*). Associated with these differences is a pronounced tapering toward the base, whereby the conidium is given on obconical shape, modified, to be sure, by the broad rotundity of the apex and a noticeable constriction at the septum.

Like other retiary species of *Arthrobotrys*, the fungus in aging cultures often gives rise to some greatly distended storage hyphae. These hyphae may remain filled with protoplasm long after other filaments have lost their contents (FIG. 4, *J*). In older cultures, too, chlamydospores not differing much in coloration, shape and size from the corresponding bodies of *A. oligospora*, are often formed. For the most part well scattered through the substratum (FIG. 4, *K-O*), they sometimes appear crowded here and there, then collectively becoming visible to the naked eye as minute yellow masses.

Though of less frequent occurrence than *Arthrobotrys oligospora* the fungus can hardly have escaped observation by all of the many mycologists that have studied the microscopic flora of decaying vegetable materials. When encountered it must in all probability have been identified usually with Fresenius' species. Indeed, the possibility even suggests itself that the value for length of conidium given by Fresenius may have been derived from an admixture of the present species with the one which unmistakably he illustrated. Rostrup (60) recently listed under the binomial *A. longispora* Preuss a species with conidia 27 to 32 μ in length and 7 to 11 μ in width; the ratio of these dimensions, 3.3, being held, justifiably enough, to distinguish the species from the supposedly similar *A. superba*, to which a corresponding ratio of 1.5

FIG. 4. *Arthrobotrys conoides*.

was attributed. My fungus, while agreeing well with Rostrup's in length of conidium, exceeds it rather markedly in width of conidium; wherefore the ratio between the averages of the two dimensions, 2.5, naturally falls below that given by the Danish mycologist. In any case the original diagnosis of *A. longispora* given by Preuss (55) would seem, like his diagnosis of *A. recta*, too deficient in specific characterization to permit application of the binomial to any particular species; and certainly, "floccis subramosis" and "sporis oblongis" provide little encouragement for its application to the species under consideration.

The fungus as developing in nematode-infested agar cultures has on many occasions been compared side by side with similar material of *Arthrobotrys oligospora*. Further, as opportunity offered during four years, more than a dozen strains of the two species, each strain isolated from a separate lot of vegetable refuse or of leaf mold, have been grown side by side in pure culture on several kinds of artificial media. Numerous variations in morphological expression, some evidently of a genetic nature, others manifestly of cultural origin, were noted. Yet in all its strains the fungus with the more slender, obconical conidia and the somewhat slower rate of mycelial extension at a temperature of 25° C., was always readily distinguishable from the faster growing fungus with the broader obovoid conidia. It is accordingly described as a new species under a name intended to be descriptive of its characteristic conidia.

***Arthrobotrys conoides* sp. nov.**

Mycelium effusum; hyphis hyalinis, septatis, plerumque 2-8 μ crassis, subinde usque 12 μ crassis protoplasmatis confertim repletis, laqueos tenaces arcuatos vel circulares in reticula saepe conjunctos evolventibus; his laqueis vermiculos nematodeos illaqueantibus, deinde tum integumentum perforantibus, tuber mortiferum intrudentibus, hyphas intus evolventibus quae carnem exhauriunt. Hyphae fertiles hyalinae, septatae, erectae, simplices, primo 150-400 μ altae, basi 4-8 μ crassae, sursum paulo fastigatae, subter apicem 2.5-5 μ crassae, apice verrucosae, irregulariter dilatatae, modo globosae modo coralloidae, usque 30 conidia in capitulum confertum aggregata ferentes, deinde identidem recrescentes alia similia vel laxiora capitula singulatim deinceps gerentes. Conidia hyalina, obconica, basi truncata, apice rotundata, ad septum paulo constricta, 19-42 μ (saepe circa 30 μ) longa, 8-15 μ (saepe circa 12 μ) lata, loculo inferiore 8-17 μ (saepe circa 12.5 μ) longa. Chlamy-

dosporae flavae, globosae vel ellipsoideae, 18–25 μ diametro, subinde angustiores, oblongo-clindraceae, 30–50 μ longae, circa 15 μ crassae.

Vermiculos nematodeos multarum specierum vulgo usque .6 mm. longos laqueans consumensque habitat in materiis plantarum putrescentibus vel in humo silvestri foris vel praecipue abunde in viridario, in Arlington, Virginia, atque prope Beltsville, Maryland.

Mycelium spreading; the vegetative hyphae hyaline, septate, except for occasional storage filaments that are densely filled with protoplasm and up to 12 μ wide, measuring mostly 2 to 8 μ in diameter, often, especially in the presence of nematodes, giving rise to hyphal bails and loops, which though at first discrete are later frequently compounded into more or less extensive networks; the bails and networks capturing nematodes through adhesion and entanglement, perforating the integument of each animal and intruding one or more globose mortiferous excrescences from which are extended assimilative hyphae to appropriate the fleshy contents. Conidiophores hyaline, erect, septate, usually not branched, mostly 4 to 8 μ wide at the base, tapering gradually to a width of 2.5 to 5 μ in attaining a height of 150 to 400 μ before bearing on a globose or more irregularly expanded tip as many as 30 conidia in dense capitate arrangement; subsequently often, following repeated elongation, giving rise successively to additional clusters of conidia. Conidia hyaline, obconical, somewhat flattened at the base, broadly rounded at the tip, usually perceptibly constricted at the septum, 19 to 42 μ (average 30 μ) long, 8 to 15 μ (average 12 μ) wide, the lower cell measuring 8 to 17 μ (average 12.5 μ) in length. Chlamydospores yellowish, globose or prolate ellipsoidal, 18 to 25 μ in diameter, or sometimes narrower, oblong-cylindrical, 30 to 50 μ long and approximately 15 μ wide.

Capturing and consuming nematodes measuring up to .6 mm. in length, referable to the genera *Acrobeles*, *Acrobeloides*, *Cephalobus*, *Diplogaster*, *Diploscapter*, *Plectus* and *Rhabditis*, it occurs in decaying plant remains and in leaf mold, often outdoors but especially abundantly in greenhouses, near Beltsville, Md., and in Arlington, Va.

ARTHROBOTRYS MUSIFORMIS

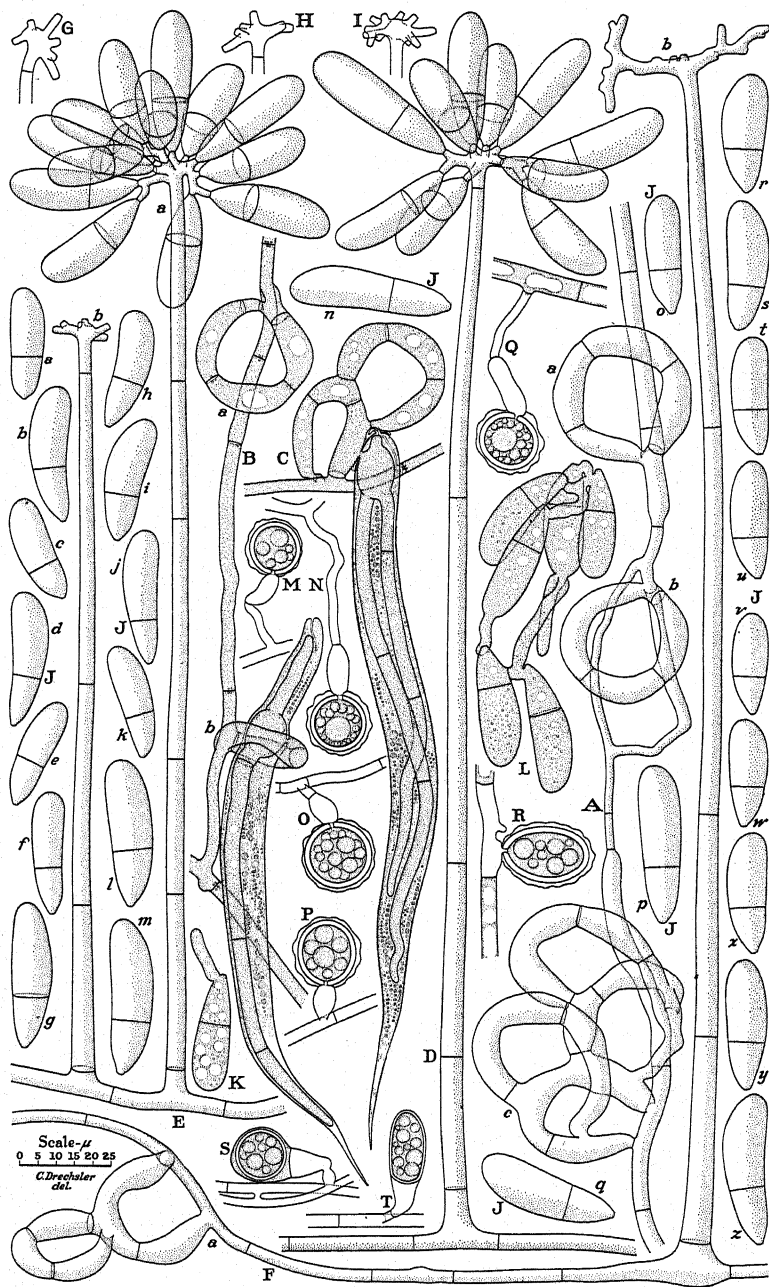
Among the predacious fungi closely similar to *Arthrobotrys oligospora* that were referred to in an earlier summary was one characterized (12: p. 138, lines 34–36; p. 139, fig. 4, A) in part as having "straight or slightly curved elongated ellipsoidal conidia borne in looser capitate arrangement on a terminal head of stubby

branches." It was first observed in isolation plate cultures planted with pieces of decaying spinach (*Spinacea oleracea* L.) roots collected near Norfolk, Va.; and has later been obtained in quantity also from samples of potting soil received from Florida, as well as from several lots of leaf mold collected in deciduous woods in Virginia. Recently Linford recorded it among various nematode-capturing fungi found in Hawaii.

In nematode-infested agar plate cultures the mycelium permeates the substratum rapidly though rather sparsely. Predacious apparatus is soon produced at irregular intervals on the individual filaments. Though of the same general type as that of the four species of *Arthrobotrys* already discussed, it is sufficiently distinctive to permit recognition of the fungus even in the absence of reproductive structures. The recurved hyphal element here usually anastomoses closer to its origin than in other retiary species, and often, indeed, the tip is united with a proximal part of the element itself (FIG. 5, *A, a, b; B, a*). Thus instead of bail-like arches, horseshoe-like arches and annular loops are formed, the latter sometimes slightly resembling the constricting rings found in some nematode-capturing fungi. Through the compounding of these elements, networks are produced (FIG. 5, *A, c; F, a*), which in the present species, however, ordinarily fail to attain the extent and intricacy known elsewhere.

Capture of nematodes, sometimes in enormous numbers, is accomplished, especially under dry conditions, combinedly through adhesion and entanglement in the anastomosed elements (FIG. 5, *B, b*); under moist conditions, and more particularly with small animals, often through adhesion alone (FIG. 5, *C*). In either case, after the integument has been narrowly penetrated, one or more globose bodies are intruded into the captive, which is thereby soon rendered incapable of further struggle. Assimilative hyphae are then extended from the globose bodies lengthwise through the interior of the animal, to appropriate the materials resulting from fatty degeneration of its organs and musculature.

The fungus is very readily isolated, and grows rapidly in pure culture on maize meal agar, producing a fairly dense mycelium, and strongly giving off the peculiar, somewhat sickeningly sweetish odor characteristic of the predacious series generally. As also on

FIG. 5. *Arthrotrichum musiformis*.

nematode-infested substrata, conidial apparatus is soon developed, usually in sufficient quantity to form a downy turf readily visible to the naked eye. In stature the individual conidiophores resemble those of *Arthrobotrys oligospora* and *A. conoides*. However, a very distinctive appearance results from the arrangement of the conidia in a loose terminal head (FIG. 5, *D*; *E*, *a*); the spores here being borne on stubby sterigmata of appreciable length that diverge in various directions from the tip of the axial stalk (FIG. 5, *E*, *b*; *F*, *b*; *G*; *H*; *I*). Production of more than a single conidial cluster on one axis has never been observed.

The conidia (FIG. 5, *J*, *a-s*) are of a shape not greatly unlike that of the plump asexual spores often produced on artificial media by the widely familiar *Helminthosporium sativum* P. B. & K.; though a noticeable protrusion of the base, not usual in the grass parasite, gives them a profile reminiscent rather of banana (*Musa sapientum* L.) fruit, thereby suggesting the name proposed for the species. Their dimensional variations would seem, for the most part, more moderate than might be inferred especially from the wide range in length indicated in the diagnosis. The 200 spore measurements from which were obtained all the relevant metrical data there presented—measurements made on specimens taken at random in equal numbers from four different strains growing in nematode-infested maize meal agar cultures—gave a distribution of values for length expressed to the nearest micron as follows: 22 μ , 1; 25 μ , 1; 26 μ , 1; 27 μ , 2; 28 μ , 3; 29 μ , 10; 30 μ , 9; 31 μ , 19; 32 μ , 20; 33 μ , 26; 34 μ , 25; 35 μ , 13; 36 μ , 20; 37 μ , 18; 38 μ , 14; 39 μ , 7; 40 μ , 4; 41 μ , 2; 42 μ , 3; 43 μ , 1; 44 μ , 1; a distribution of values for width as follows: 8 μ , 4; 9 μ , 18; 10 μ , 77; 11 μ , 79; 12 μ , 21; 13 μ , 1; and a distribution of values for length of the proximal cell as follows: 8 μ , 1; 9 μ , 4; 10 μ , 26; 11 μ , 54; 12 μ , 62; 13 μ , 31; 14 μ , 12; 15 μ , 9; 16 μ , 1. It is evident that on the whole the conidial measurements here appreciably exceed those submitted by Rostrup (60) for his *Arthrobotrys longispora*; though the ratio of length to width, using the averages computed for these dimensions, agrees well with the corresponding ratio given for the Danish fungus. In any case the present species is so conspicuously different from *A. superba* in the

general appearance of its conidial apparatus, that it hardly could have been the form with which Rostrup was concerned.

Germination takes place whenever conidia come in contact with a moist substratum (FIG. 5, *K*), and is often followed by anastomosis with sporophores, mycelial filaments, other germ tubes, or other conidia (FIG. 5, *L*). In old cultures, after such vegetative union, a conidium sometimes gives rise to a yellowish chlamydospore within its distal segment (FIG. 5, *S*, *T*). Chlamydospores produced within conidia are generally smaller than those formed on lateral branches arising from vegetative filaments in the substratum (FIG. 5, *M-R*); these being remarkable, besides, in the wide separation of the enveloping wall into a somewhat folded, thin, outer layer and a thick, smooth, spherical inner layer. This separation, together with the inflated condition of the adjacent cell, makes for an appearance more than a little suggestive of the sexual apparatus of some oömycetes.

Arthrobotrys musiformis sp. nov.

Mycelium effusum; hyphis hyalinis, septatis, plerumque 2-9 μ crassis, laqueos tenaces arcuatos vel circulares in reticula interdum conjunctos evolventibus; his laqueis reticulisque vermiculos nematodeos illaqueantibus, deinde tum integumentum perforantibus, tuber mortiferum intrudentibus, hyphas intus evolventibus quae carnem exhauriunt. Hyphae fertiles hyalinae, septatae, erectae, simplices, 200-500 μ altae, basi 5-9 μ crassae, sursum paulo fastigatae, subter apicem 2.5-4 μ crassae, apice brevi-ramosae, 5-15 conidia in capitulum laxum ferentes. Conidia hyalina, ellipsoidea, ad basin versus paulo attenuata, recta vel leviter curvata, 22-44 μ (saepe circa 33.9 μ) longa, 7.5-12.7 μ (saepe circa 10.4 μ) lata, loculo inferiore 8-16.4 μ (saepe circa 11.7 μ) longo. Chlamydosporae flavidae, globosae vel interdum ellipsoideae, 14-22 μ (saepe circa 17.5 μ) diametro.

Vermiculos nematodeos multarum specierum vulgo usque .6 mm. longos laqueans consumensque habitat in radicibus putrescentibus *Spinaciae oleraceae* prope Norfolk, Virginia, in humo pingui prope Coconut Grove, Florida, in humo silvestri prope Beltsville, Maryland, atque in Arlington, Virginia.

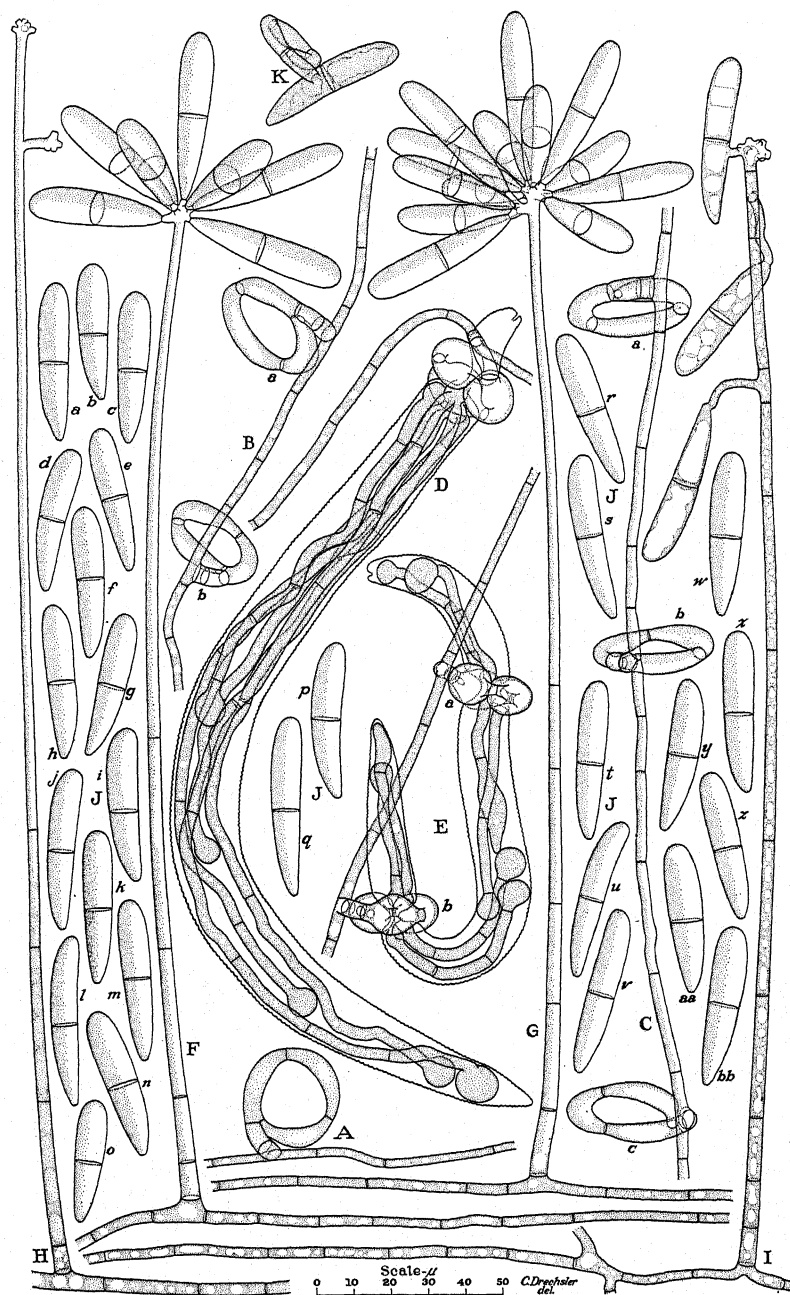
Mycelium spreading; the vegetative hyphae hyaline, septate, mostly 2 to 9 μ wide, often, especially in the presence of nematodes, giving rise to horseshoe-like hyphal arches and loops that may remain discrete, or in numbers not usually exceeding 6 may be compounded into networks—the individual circular loops mostly composed of 3 to 5 arcuate cells surrounding an aperture 15 to 25 μ wide; the loops and networks capturing nematodes through adhesion and entanglement, perforating the integument of each ani-

mal and intruding one or more globose mortiferous excrescences from which are extended assimilative hyphae to appropriate the fleshy contents. Conidiophores hyaline, septate, erect, not branched below, 200 to 500 μ high, 5 to 9 μ wide at the base, tapering upward gradually to a width of 2.5 to 4 μ near the tip, where are borne on divergent, slightly tapering, simple or branched sterigmata, mostly 2 to 3 μ wide and 3 to 10 μ long, usually 5 to 15 conidia in loose capitate arrangement. Conidia hyaline, ellipsoid, straight or slightly curved, broadly rounded at the wider distal end, tapering noticeably toward the slightly protruded base, 22 to 44 μ (average 33.9 μ) long, 7.5 to 12.7 μ (average 10.4 μ) wide, the lower and smaller cell 8 to 16.4 μ (average 11.7 μ) long. Chlamydospores yellow, globose or less frequently ellipsoidal, mostly 14 to 22 μ (average about 17.5 μ) in diameter.

Capturing and consuming nematodes measuring up to .6 mm. in length, referable to the genera *Acrobeles*, *Acroboloides*, *Cephalobus*, *Diplogaster*, *Diploscapter*, *Plectus* and *Rhabditis*, it occurs in decaying spinach roots near Norfolk, Va., in potting soil near Coconut Grove, Fla., and in leaf mold near Beltsville, Md., and in Arlington, Va.

ARTHROBOTRYS DACTYLOIDES

The strangling predacious fungus set forth synoptically (13: p. 268, lines 25-32; p. 269, fig. 13, A-C) as bearing elongated uni-septate conidia in open capitate arrangement, makes its appearance now and then in nematode-infested agar-plate cultures to which have been added small quantities of leaf mold or of other decaying vegetable materials. Its development is conditioned by a consistency of the substratum soft enough to permit nematodes to move freely through it, rather than only on the surface of it. For apparently the organs of capture, though sometimes jostled to the surface by large nematodes and earthworms, often, indeed, into angular positions conveniently exposing their remarkably uniform make-up (FIG. 6, A, B), are regularly produced in the substratum beneath and a little to one side of the parent filaments, which, as in other predacious forms, are sparsely distributed and follow somewhat straightforward courses (FIG. 6, C, a-c). These organs originally consist of rings formed separately in planes approximately at right angles with the parent hypha, to which they are attached at intervals rarely less than 50 μ by short, stout, two-celled

FIG. 6. *Arthrobotrys dactyloides*.

stalks. Unlike the hyphal bails and loops of the five retiary species already discussed, which, apart from entanglement and adhesion exert no violence externally on ensnared nematodes, the stalked ring of the form under discussion constricts its captive through extraordinary swelling and contraction of its three component cells, until musculature and organs are virtually, if not wholly, severed within the strangulated integument. The constricting action here, proceeding with gradual reduction and eventual cessation of the captive's violent struggles, is probably without parallel among carnivorous plants for outward appearance of implacableness and malignancy. It accomplishes in a much different manner what is accomplished in retiary and knobbed species through intrusion of a globose body—that is, virtual severance and paralysis of the animal, making possible the extension of assimilative hyphae through the fleshy interior (FIG. 6, *D, E*). In the present species these hyphae regularly terminate in a bulbous enlargement—a curious modification, the utility of which is not yet apparent.

Despite the astonishing manner of bringing about the death of nematodes ensnared in its constricting rings, the number of animals destroyed by the fungus is usually moderate in comparison to those consumed under favorable conditions by allied retiary species. As a result, conidial apparatus is produced rather sparsely. The fertile hyphae resemble the corresponding elements of *Arthrobotrys musiformis* in general stature, even if, perhaps, on the whole a little shorter and slightly less sturdy. At the tip, moreover, they terminate in perceptibly shorter sterigmata, so that the conidial heads borne on them show a slightly more compact central arrangement (FIG. 6, *F, G*). To be sure, the sterigmata are not always collected in a single terminal group, some occasionally being found on a lateral spur a short distance from the apex (FIG. 6, *H*), there bearing conidia in a recognizably separate subsidiary cluster.

In most cultures the conidia (FIG. 6, *J, a-z, aa, bb*) are uniformly uniseptate and of an elongated shape only rather poorly described in the epithet that for lack of a classical term equivalent to "cigar-shaped" is proposed for the fungus. Occasionally, however, material is found showing an admixture of conidia (FIG.

18, *K*, *a-p*) shortened and widened in varying degree. The more pronouncedly modified specimens approach an ovoid shape, and frequently contain two septa placed so as to delimit a large swollen dolioform middle segment from the two smaller conoidal end segments (FIG. 18, *K*, *d*, *e*, *f*, *i*, *j*, *l*, *m*, *n*, *p*). This variation in conidial morphology appeared so much in excess of the variation usual in members of the predacious series that it was earlier held as possibly indicative of a separate species (14: p. 356, lines 31-37; p. 357, lines 1-3, 19-25, fig. 18, *A*, *B*). However, pure cultures made from the swollen biseptate conidia showed no important difference from cultures started with the slender uniseptate spores. Further evidence of identity is provided in the vegetative fusion of germ tubes from both types of spores with one and the same hypha (FIG. 18, *I*, *J*); anastomoses with slender and with swollen spores taking place indiscriminately, and in no wise less freely than when slender conidia alone are present (FIG. 6, *I*).

Sometimes conidia in germinating give rise individually to a predacious ring (FIG. 6, *K*) of slightly smaller dimensions than the similar organs formed on mycelial hyphae. A nematode ensnared in such a ring is, of course, not held in place, but with the conidium clamped to its body continues for a few hours to move about, at first frantically, then more feebly, offering a ludicrous yet pitiful sight. The increasing constriction finally brings about a cessation of movement, whereupon, if not before, penetration is effected, followed by intrusion of assimilative hyphae and appropriation of the fleshy contents. An altogether similar ectoparasitic relationship occasionally replaces the more usual predacious relationship when large vigorous nematodes belonging often to species of *Rhabditis* and of *Mononchus*, tear rings wherein they have become ensnared from their attachments on the mycelial hyphae, and then continue to move about until overtaken by paralysis.

As might be inferred from previous remarks, the fungus produces uniseptate conidia so often to the exclusion of biseptate specimens that mycologists encountering its reproductive apparatus in the course of routine examinations would hardly ever have reason to suspect any possible eligibility for inclusion in *Dactylaria*. It is accordingly referred, though not without reluctance, to the genus *Arthrobotrys*. Of the five other species of *Arthrobotrys*

herein discussed, it would seem most closely related to *A. musiformis*, whose frequently discrete circular loops bear a resemblance to the stalked constricting nooses of the present form not shared by the hyphal bails and reticula of the other retiary congeners. However, its most intimate kinship is very probably with the fungus to be described as *Dactylaria brochopaga*. This fungus it resembles closely not only in outward habit and in design of predacious organs, but also in producing on maize meal agar-plate cultures a somewhat lustrous radiating mycelium whose hyphae under the microscope appear disposed in nearly parallel arrangement.

***Arthrobotrys dactyloides* sp. nov.**

Mycelium effusum; hyphis hyalinis, septatis, plerumque $2-5\mu$ crassis, laqueos circulares $20-32\mu$ latos in 3 cellulis arcuatis $12-28\mu$ longis medio $4.5-7\mu$ extremo $2.5-6\mu$ crassis consistentes ex ramulo biloculari circa $7-14\mu$ longo $4-5\mu$ crasso proferentibus; his laqueis vermiculos nematoideos illaqueantibus, deinde tum per contractionem inflationemque trium cellularum animal magnopere comprimentibus, ita hoc trucidantibus, statim integumentum perforantibus, hyphas intus evolventibus quae carnem exhauriunt. Hyphae fertiles hyalinae, septatae, erectae, plerumque $200-400\mu$ altae, basi $4-6\mu$ crassae, sursum leviter fastigatae, apice $2.5-3.5\mu$ crassae, $4-13$ conidia in capitulum laxum subinde in duo capitula distincta aggregata ferentes. Conidia hyalina, elongata-ellipsoidea, aliquantulum digitiformia, recta vel leviter curvata, apice late rotundata, deorsum aliquantum attenuata, basi truncata, $32-48\mu$ (saepe circa 41.6μ) longa, $7-9.5\mu$ (saepe circa 8.4μ) lata, loculo inferiore $16-23\mu$ (saepe circa 20.5μ) longo; sed quandoque incrassata, abbreviata, usque 18μ lata, tum saepe 2-septata, loculo medio majore quam alteriis.

Vermiculos nematodeos multarum specierum vulgo usque .6 mm. longos laqueans consumensque habitat in foliis et radicibus plantarum putrescentibus prope Beltsville, Maryland, atque in humo silvestri in Arlington, Virginia.

Mycelium spreading; the vegetative hyphae hyaline, septate, mostly 2 to 5μ wide, often, especially in the presence of nematodes, producing underneath and at right angles to their respective axes approximately circular rings, 20 to 32μ in diameter, composed individually of 3 arcuate cells, 12 to 28μ long, 4.5 to 7μ wide in the middle and 2.5 to 6μ wide at the ends—the first and third of the cells being united to one another as well as to the distal part of a somewhat curved sturdy supporting branch 7 to 14μ long, 4 to 5μ wide, and consisting usually of 2 cells whereof the proximal one is generally the shorter; following ensnarement of a nematode, the individual ring through contraction and inflation of its component arcuate cells constricting the animal to death or into a state

of reduced activity preceding death, then perforating the integument and giving rise to assimilative hyphae that appropriate the fleshy contents. Conidiophores hyaline, septate, erect, mostly 200 to 400 μ high, 4 to 6 μ wide at the base, tapering gradually upward to a width of 2.5 to 3.5 μ at the tip, there bearing on sterigmata 1 to 5 μ long and 2 to 3 μ wide, from 4 to 13 conidia usually in a single loose head, more rarely in two somewhat distinct clusters. Conidia hyaline, usually elongate ellipsoidal or somewhat digitiform, straight or slightly curved, tapering noticeably from the broadly rounded wider distal end toward the narrower truncate basal end, 32 to 48 μ (average 41.6 μ) long, 7 to 9.5 μ (average 8.4 μ) wide, with the single septum 16 to 23 μ (average 20.5 μ) from the base; but occasionally becoming wider and shorter, measuring as much as 18 μ in width and as little as 25 μ in length, then often 2-septate, with the inflated middle cell greatly exceeding the end cells in size.

Capturing and consuming nematodes measuring up to .6 mm. in length, referable to the genera *Acrobeles*, *Acrobeloides*, *Cephalobus*, *Diplogaster*, *Diploscapter*, *Plectus*, *Rhabditis* and *Mononchus*, it occurs in decaying leaves and roots of many plants near Beltsville, Md., and also in leaf mold in deciduous woods in Arlington, Va.

DACTYLELLA BEMBICODES

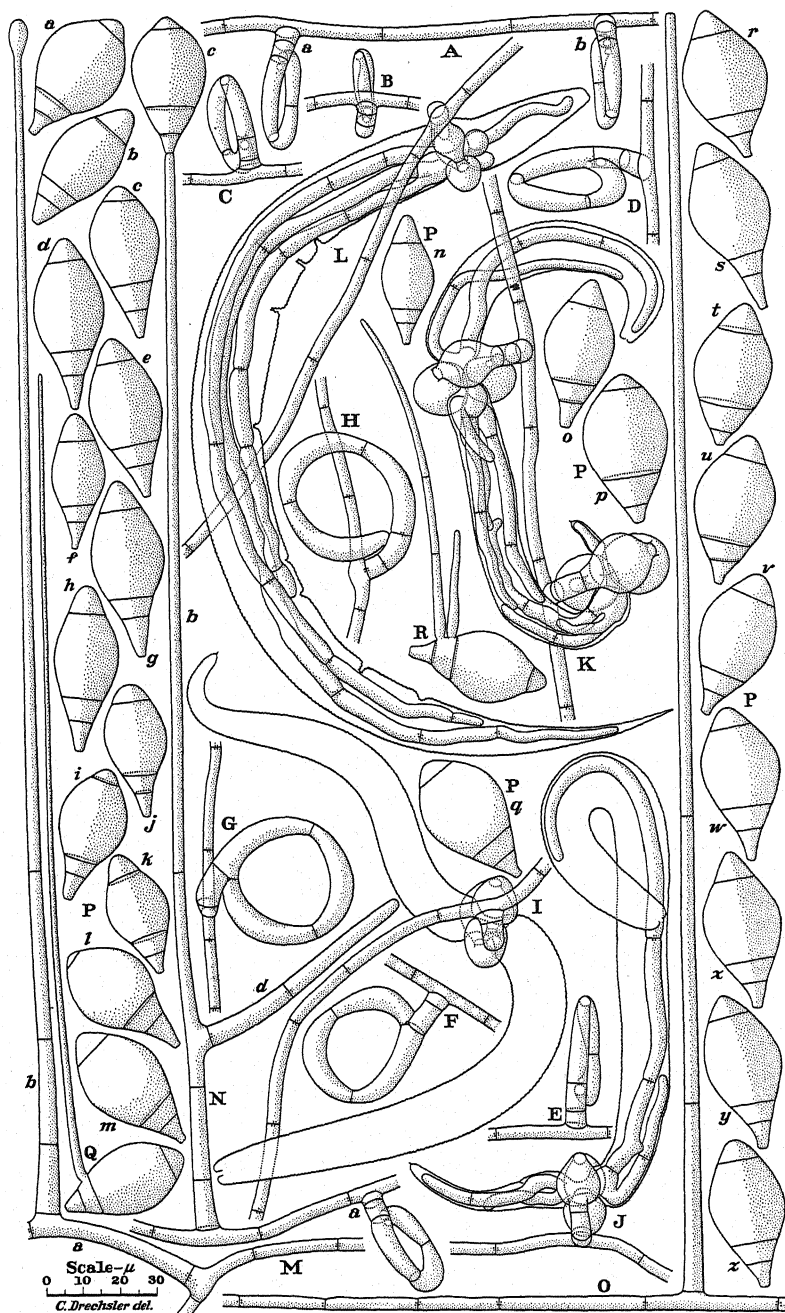
A fungus obtained occasionally in nematode-infested agar-plate cultures following the addition of small quantities of miscellaneous leaf mold, and much more frequently following addition of the dark friable material from the interior of decaying acorns, produces rings very similar to those of *Arthrobotrys dactyloides* both in cellular make-up and in positional relationship to parent hypha and substratum (FIG. 7, A-H). Sometimes the predacious organs here have given slightly larger measurements than in the species already described, yet for the most part differences between the two forms with respect to the robustness of these structures are not readily apparent. Capture (FIG. 7, I) and invasion (FIG. 7, J, K, L) of prey likewise proceeds as in *A. dactyloides*, except that here the assimilative hyphae generally terminate after the usual manner of mycelial filaments rather than in bulbous enlargements. Though the constricting ring would seem designed especially for the capture of nematodes, specimens of rotifers have

occasionally been found squeezed to death in agar cultures moist enough to encourage multiplication of these animals (FIG. 18, N).

The conidiophores produced by the fungus on nematode-infested agar cultures are usually too sparsely distributed on the substratum to make up a stand at all easily discernible with the naked eye. On microscopic inspection, however, they appear as tall, erect, sturdy hyphae, which, individually, for some time after attaining definite height are continuous with the swollen tip (FIG. 7, M) that gradually develops into the terminal conidium (FIG. 7, N). Somewhat rarely a second conidium may be formed following elongation of the hypha from below the attachment of the first. As a conidiophore approaches or attains maturity it frequently puts out a lateral branch some short distance, usually about $50\ \mu$, above the base (FIG. 7, N, d). This branch grows into a second conidiophore (FIG. 7, M, b), gradually assuming an erect position as the parent hypha (FIG. 7, M, a) declines toward the substratum. Where no such secondary development ensues a conidiophore may retain its upright posture for a considerable period after the spore has fallen off (FIG. 7, O).

The fungus, though readily isolated, grows very slowly in pure culture. On maize meal agar white aerial mycelium is produced without, however, any vestige of conidial apparatus. Nor has such apparatus been seen in pure culture on other media.

After its principal morphological features had been briefly set forth (14: p. 356, lines 5-26; p. 357, lines 15-18, fig. 17, A, B, C), the fungus was referred to incidentally (17, 18) as probably being identical with *Monacrosporium elegans*. The likelihood of such identity was suggested by a general resemblance of the conidia (FIG. 7, P, a-z) to those described and figured in the original account of Oudemans' species. Closer comparison has, however, always revealed serious differences in detail. Conidiophores so short as not to exceed the length indicated in Oudemans' diagnosis, $250\ \mu$, have been seen only rarely in my material, and then mostly after special search. Measurements of the largest conidia in cultures started with materials collected in more than a dozen different places have failed to disclose even a single specimen having a length of $50\ \mu$, the lower limit of the range given for this dimension in the description of *M. elegans*. The discrepancy can not

FIG. 7. *Dactylella bembicodes*.

well be explained away as resulting from wide variability, since the present fungus, unlike many other members of the predacious series, has consistently shown only rather moderate variations in conidial dimensions, always over approximately the same range. Thus, the 100 spore measurements from which were obtained the relevant metric data presented in the accompanying diagnosis—measurements made on specimens taken at random in equal numbers from four different strains growing in nematode-infested maize meal agar plate cultures—gave a distribution of values for length expressed to the nearest micron as follows: 34 μ , 2; 36 μ , 2; 37 μ , 2; 38 μ , 2; 39 μ , 5; 40 μ , 10; 41 μ , 18; 42 μ , 14; 43 μ , 20; 44 μ , 12; 45 μ , 5; 46 μ , 4; 47 μ , 3; 48 μ , 1; and a distribution of values for width as follows: 14 μ , 1; 15 μ , 1; 16 μ , 1; 17 μ , 3; 18 μ , 6; 19 μ , 18; 20 μ , 29; 21 μ , 27; 22 μ , 12; 23 μ , 2.

It is true that more pronounced differences than those just noted have not always been deemed sufficient to separate from *Monacrosporium elegans* fungi having conidia of somewhat similar ventricose shape. Marchal (44), for example, assigned to Oudemans' species a form with spores only 20 to 40 μ long and 15 to 18 μ wide. This form, no less than *M. ovatum* later described by Petch (53) as having conidia 26 to 36 μ long and 12 to 16 μ wide, would seem, however, definitely too small to be identified with *M. elegans*, or, for that matter, with the predacious fungus under discussion. Again, Rostrup (59) listed as *M. elegans* a plant whose symmetrically and broadly spindle-shaped 4-septate conidia show far better agreement with those of the species to be subsequently treated under the binomial *Dactylella ellipsospora*. It must be apparent from a consideration of the several distinct nematode-capturing forms with ventricose conidia presented herein, that such swollen spores, however infrequent elsewhere, are far from unusual in the predacious series of which *M. elegans* most probably is a member. Certainly the conidia of the present form correspond more closely to the 3-septate spores usual in *Dactylaria thaumasia* and frequent in *Dactylella gephyropaga* than they correspond to the spores described in the original account of *M. elegans*. The fungus evidently represents a new species, for which an epithet meaning "top-shaped," suggested by its characteristically turbinate conidia, may not be inappropriate.

Dactylella bembicodes sp. nov.

Mycelium effusum; hyphis hyalinis, septatis, plerumque 2–5 μ crassis, laqueos circulares 22–37 μ latos in 3 cellulis arcuatis 14–30 μ longis medio 4.5–7 μ extremo 3–6 μ crassis consistentes ex ramulo biloculari circa 7–14 μ longo, 4.5–6 μ crasso proferentibus; his laqueis vermiculos nematodeos illaqueantibus, deinde tum per contractionem inflationemque trium cellularum animalia magnopere comprimentibus, ita haec trucidantibus, statim integumentum perforantibus, hyphas intus evolventibus quae carnem exhauriunt. Hyphae fertiles hyalinae, erectae, septatae, 250–500 μ altae, basi 5–7.5 μ crassae, sursum leviter fastigatae, apice 2–3.2 μ crassae, ibi unicum conidium ferentes. Conidia hyalina, speciose turbinea, 34–48 μ (saepe circa 42 μ) longa, 16–23 μ (saepe circa 20 μ) lata, vulgo 3-septata: loculo infimo obconico, saepe circa 7.6 longo; loculo antepaenultimo disciformi, saepe circa 5.7 longo; loculo paenultimo dolioformi, ventricosus, saepe circa 22.5 μ longo; loculo summo apice rotundato, saepe circa 6.2 μ longo.

Vermiculos nematodeos multarum specierum etiam rarissime rotifera laqueans consumensque habitat exigue in humo silvestri sed abunde praecipue in glandibus quernis *Quercus Prini* putrescentibus prope Beltsville, Maryland, et in Arlington, Virginia.

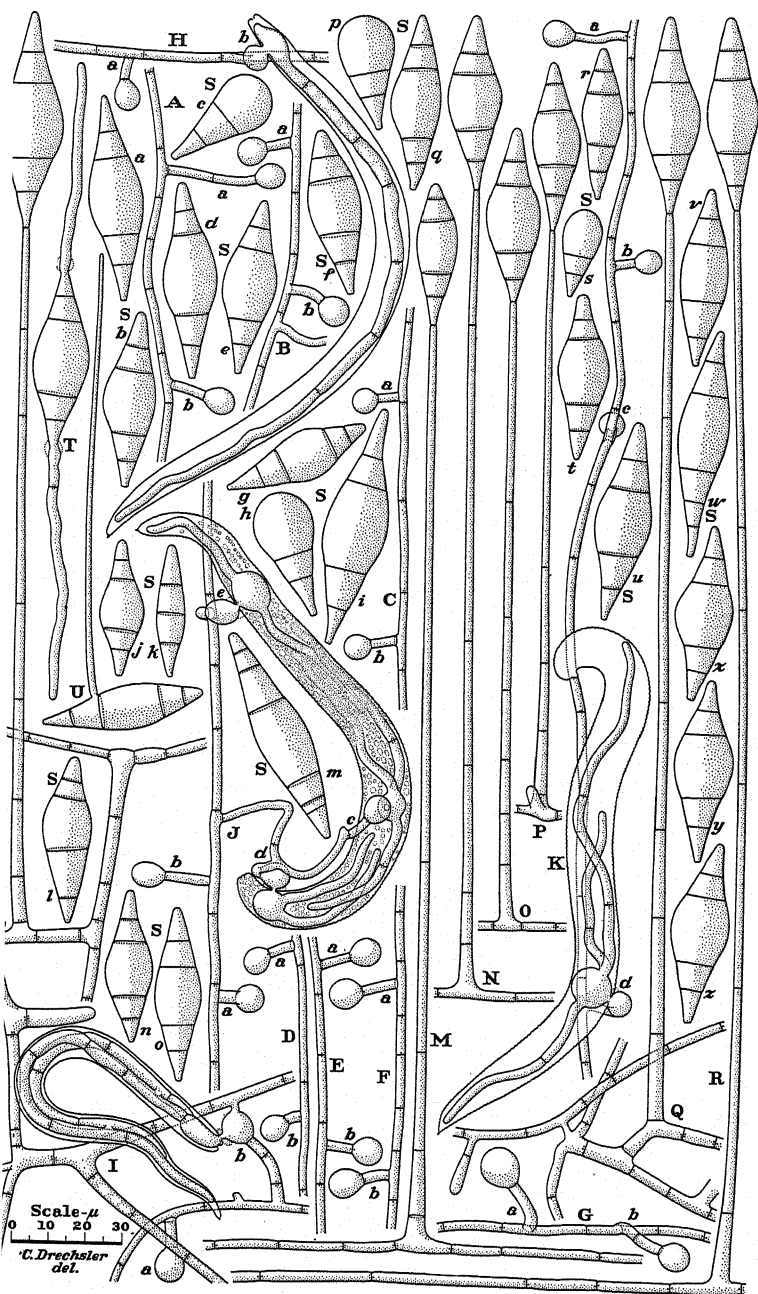
Mycelium spreading; vegetative hyphae hyaline, septate, mostly 2 to 5 μ wide, often, especially in the presence of nematodes, producing underneath and at right angles to their axes approximately circular rings 22 to 37 μ in outside diameter, composed individually of 3 arcuate cells 14 to 30 μ long, 4.5 to 7 μ wide at the middle and 3 to 6 μ wide at the ends—the first and third of the cells being united usually to one another as well as to the distal end of the sturdy, somewhat curved or straight supporting branch 7 to 14 μ long, 4.5 to 6 μ thick, and consisting usually of 2 cells, whereof the proximal one is generally the shorter; following ensnarement of a nematode, the individual ring, through contraction and inflation of its component arcuate cells constricting the animal to death or into a state of reduced activity preceding death, then perforating the integument and extending lengthwise throughout the body assimilative hyphae that appropriate the fleshy contents. Conidiophores hyaline, erect, septate, 250 to 500 μ , mostly 300 to 450 μ high, 5 to 7.5 μ wide at the base, tapering gradually upward to a diameter of 2 to 3.2 μ at the tip, whereon is borne usually a single conidium. Conidia hyaline, handsomely top-shaped, broadly rounded at the apex, tapering toward the slightly protruding truncate base, 34 to 48 μ (average 42 μ) long, 16 to 23 μ (average 20 μ) wide, regularly divided by 3 septa into 4 cells: the basal cell obconical, with an average length of 7.6 μ ; the antepenultimate cell disciform, with an average length of 5.7 μ ; the penultimate cell ventricose or inflated barrel-shaped, with an average length of 22.5 μ ; the apical cell conico-hemispherical, with an average length of 6.2 μ .

Capturing and consuming nematodes measuring up to .6 mm. in length, referable to the genera *Acrobeles*, *Acrobelloides*, *Cephalobus*, *Diplogaster*, *Diploscapter*, *Plectus*, *Rhabditis* and *Mononchus*, and very rarely also rotifers, it occurs rather sparingly in leaf mold generally, but more abundantly especially within decaying acorns (*Quercus Prinus* L.), near Beltsville, Md., and in Arlington, Va.

DACTYLELLA ELLIPSOSPORA Grove

Though in recent times Zopf's discoveries relative to the capture of nematodes by *Arthrobotrys oligospora* appear finally to have become widely recognized, it is less generally known that in the same paper in which these discoveries were published he set forth also, even if somewhat briefly, the destruction of nematodes by another predacious fungus referred to under the name *Monosporidium repens*. The latter species was described as forming on the surface of its substratum a delicate white coating composed of narrow septate filaments from which arise simple, relatively short conidiophores individually bearing at their tips a solitary, non-septate, colorless conidium, globose or pyriform in shape, and measuring 8 to 10 μ along its longest axis. The strange thing, according to the account, is that infection proceeds always from the conidium; this structure applying itself to the nematode, mostly at the forward end, and then intruding into the body a short, stout infection-vesicle from which two or three filaments are extended through the interior of the animal to the caudal end. Further development was reported to take place by the production from the endozoic hyphae of lateral branches that after perforating the animal's integument form new conidia outside to repeat the cycle.

In one of my summaries (12: p. 139, lines 24-26, fig. 7, A, B, C; p. 140, lines 1-7), and again somewhat more fully in a later paper (15: p. 138-139), the structures taken by Zopf for conidia were presented as specialized predacious organs owing their functional efficacy to adhesive material secreted by them. At all events adhesive organs corresponding well to Zopf's supposed conidia have been seen frequently in nematode-infested agar-plate cultures following the addition of leaf mold, or of bits of decaying wood. Sometimes nearly spherical but more often perceptibly prolate,

FIG. 8. *Dactylella ellipsospora*.

they vary in length from 7 to 11.5 μ , and in width from 6.5 to 10 μ (FIG. 8, *A-G: a-b; H, a; I, a; J, a, b; K, a-c*). The stalks bearing them are mostly unicellular, 2.4 to 3 μ wide and 5 to 10 μ long, though examples may be found as little as 3 μ (FIG. 8, *D, b*) or as much as 25 μ (FIG. 8, *A, a*) in length; the longer specimens often consisting of two or more cells (FIG. 8, *A, a; I, b*). Generally the stalks arise at nearly right angles from the rather straightforward, septate hyphae, mostly 2 to 3 μ wide, that make up the sparse mycelium. Capture of nematodes is effected through adhesion on the globose cells, the adhesive material here, as in retiary species, becoming visible as a sizable deposit after the struggles of the animal have stimulated its secretion for some time (FIG. 8, *H-K*). In the absence of all structural ensnarement, only somewhat small animals are usually held, though larger prey may be taken when because of moist conditions the mechanical leverage of struggling captives has been reduced. Penetration of the integument, intrusion of a bulbous outgrowth, extension therefrom of assimilative hyphae through the paralyzed body, and appropriation of the degenerating fleshy contents, follow in their familiar sequence.

From the prostrate superficial mycelial filaments are put forth erect, septate conidiophores (FIG. 8, *L-R*) 150 to 300 μ high, 3.2 to 5 μ wide at the base, tapering upward to a width of 1.5 to 2.5 μ at the tip, whereon is borne a solitary conidium. Occasionally a second spore is formed, following elongation of the fertile hypha. More frequently a branch from the basal portion of an aging conidiophore grows into a new conidiophore, assuming an erect position as the old one declines to the substratum. The conidia thus produced (FIG. 8, *S, a-s*) are for the most part broadly spindle-shaped, rounded at the ends, and divided by four septa into five cells, of which the middle, barrel-shaped one is usually by far the largest. They vary in length between observed extremes of 24 μ and 65 μ , and in width between observed extremes of 7.5 μ and 19 μ ; some of the longer specimens containing as many as six cross-walls (FIG. 8, *S, m*), while most of the shortest specimens are of atypical obconical shape (FIG. 8, *S, c, h, p, s*) with only two septa—these corresponding evidently to the two proximal partitions of the four more commonly present. Germination takes place by the production frequently of two polar germ tubes (FIG.

8, T); but on relatively dry substrata a delicate conidiophore (FIG. 8, U) is often thrust up to bear a secondary conidium, which is regularly somewhat smaller than the primary one from which it originated.

The conidial apparatus in question shows fairly satisfactory agreement with Grove's (28) description of his *Dactylella ellipso-spora*. The range for length of conidium indicated in that description, 40 to 50 μ , coincides with the usual range for this dimension in my material; while the range indicated by Grove for width of conidium, 16 to 18 μ , if somewhat higher than would seem representative of my fungus, is yet exceeded by the maximum value for this dimension given in the preceding paragraph. Equally good, or perhaps even better agreement is found when comparison is extended to *Monacrosporium leporinum*, described by Bubák (6) as having conidiophores 180 to 300 μ long together with conidia 42 to 53 μ long, 13 to 18.5 μ wide, and composed of five cells, the median one exceeding the others in size.

The nematode-capturing fungus whose predacious apparatus is evidently identical with the supposed conidia discussed by Zopf in 1888, must on grounds of priority be referred to *D. ellipso-spora* described two years earlier from true reproductive structures. With this species *M. leporinum* described two decades later from reproductive structures of very similar morphology appears to be synonymous, as would seem to be, also, though somewhat more doubtfully, the *M. elegans* of Rostrup. On the other hand, the *D. ellipso-spora* of Smith (65), with spores measuring 40 μ in length and 10 to 12 μ in width, may with equal or perhaps greater probability, have been identical with the species herein to be described as *D. lysipaga*.

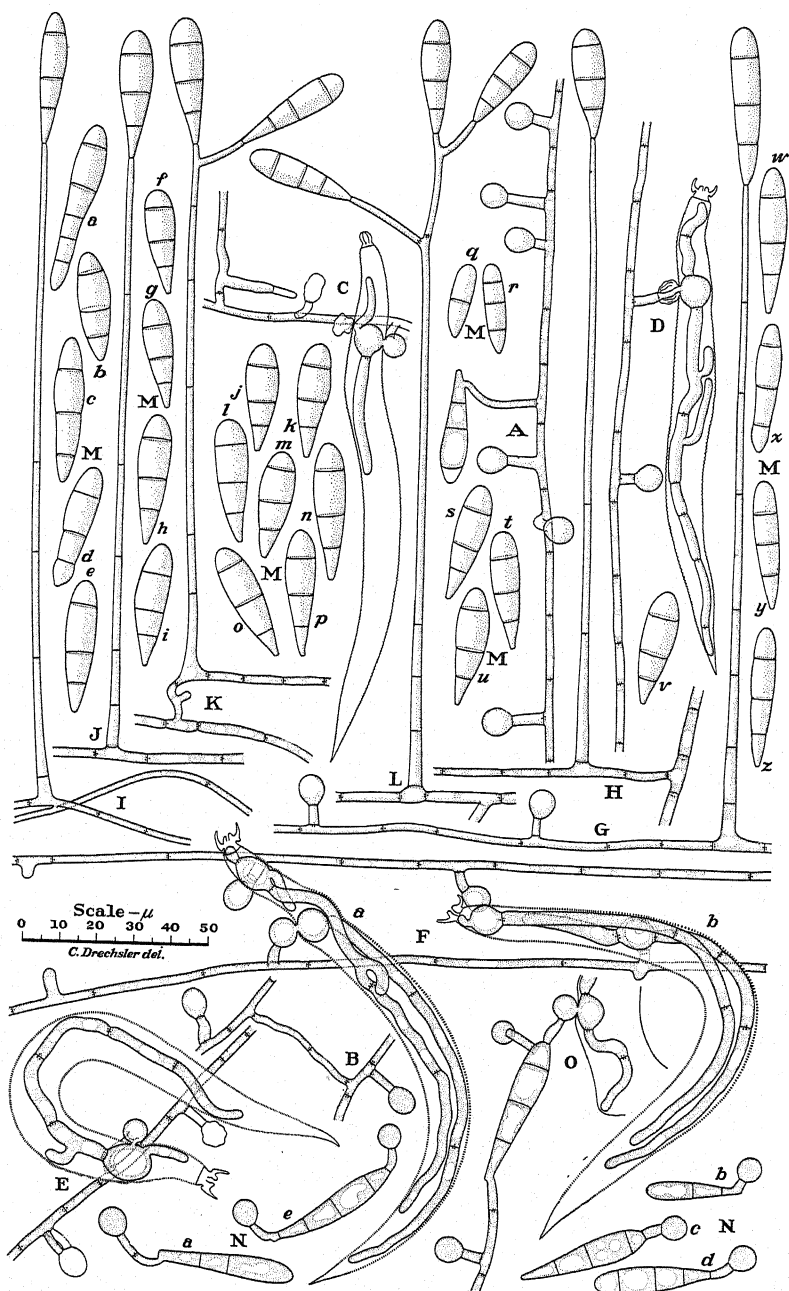
In pure culture on maize meal agar the fungus grows well, giving rise to a moderately dense submerged mycelium of somewhat radiating aspect. Sporulation is frequently wholly absent, but can often be brought on by exposure to direct sunlight for brief periods. Reproductive apparatus obtained through such exposure is, however, mostly so variable that despite the generally more robust conidiophores and larger conidia characteristic of the species, separation from *Dactylella lysipaga* in similarly treated cultures is usually not easy. For definite identification, therefore,

the fungus should preferably be viewed also in nematode-infested cultures, where its predacious organs distinguish it very readily from any other known species with typically 4-septate conidia.

DACTYLELLA ASTHENOPAGA

A fungus with predacious knobs (FIG. 9, *A*, *B*) perceptibly smaller than those formed by *Dactylella ellipsospora* often makes its appearance in maize meal agar cultures following the addition of small quantities of the black friable material from the interior of decaying acorns; and much less frequently following the addition of miscellaneous leaf mold. The knobs in the present species ordinarily appear operative only in the capture of nematodes belonging to the genus *Bunonema*—phlegmatic animals that after being introduced with the decaying forest refuse multiply slowly in the cultures to attain respectable numbers in two or three weeks. On especially moist agar culture media small individuals of more energetic genera have been seen captured, indicating that the selection usually evident results from the inability of the adhesive organs to hold the more active eelworms when the physical condition of the substratum is such as to furnish effective leverage. Once an animal is held, narrow perforation of the integument, intrusion of a mortiferous excrescence, extension of assimilative hyphae lengthwise, and appropriation of the degenerating fleshy contents, take place as in other species with adhesive predacious apparatus (FIG. 9, *C-E*; *F*, *a*, *b*).

The conidiophores (FIG. 9, *G-J*) arising here and there from the sparse mycelium in nematode-infested agar cultures, are rather frail in appearance when compared with those of most other fungi subsisting through the capture of eelworms. Usually and typically they are simple and bear a single conidium; yet at times a second conidium is produced on a short branch attached some distance below the apex (FIG. 9, *K*); and, more rarely still, two lateral branches are present, allowing a production altogether of three conidia (FIG. 9, *L*). Such distal ramification is no doubt akin to the proximal branching frequent in this as in related species, whereby young conidiophores are put forth to assume gradually an erect posture as the old axis declines to the substratum.

FIG. 9. *Dactylella asthenopaga*.

In pure culture on maize meal agar the fungus grows readily, giving rise to a sparse stand of conidiophores, on which are borne conidia mostly rather irregularly clavate in shape, measuring 20 to $46\ \mu$ in length, and partitioned by one to five cross-walls (FIG. 9, *M*, *a-d*, *q*, *r*, *x*). On nematode-infested agar plate cultures, a better approximation to uniformity, and apparently a more trustworthy expression of the morphology of the species is obtained, the conidia here, more regularly clavate in shape, measuring 26 to $36\ \mu$ in length, and with few exceptions, containing three cross-walls (FIG. 9, *M*, *e-p*, *s-w*, *y*, *z*). Germination often is initiated by direct production of one or two stalked knobs (FIG. 9, *N*, *a-e*); the residual protoplasm in the conidium then being utilized to put forth a germ hypha likewise beset with these predacious organs (FIG. 9, *O*).

With respect to size and shape of conidium, the fungus would seem to fit fairly well the description of *Monacrosporium sarcopodioides* (Harz) Berl. & Vogl. as given by Saccardo (62) and by Lindau. However, the sporophores of *M. sarcopodioides*, characterized as continuous, ascending, and equal in length to the conidia, differ so much from the septate, erect and relatively tall fertile hyphae of the present form that identity of the two organisms appears unlikely. Nor, indeed, can a better agreement be discovered by consulting Harz's original account (31) of his *Acrothecium sarcopodioides*, wherein the fertile hyphae are described as "schwach aufsteigend oder neiderliegend."

The somewhat feebly predacious fungus under consideration is accordingly described as a new species under a name compounded of two words meaning "weak" and "trap" respectively.

Dactylella asthenopaga sp. nov.

Mycelium effusum; hyphis hyalinis, septatis, $1.7-3\ \mu$ crassis, bullas tenaces globosas vel ellipsoideas plerumque $6.5-8\ \mu$ longas, $6-7.5\ \mu$ latas ex ramulo recto, $3-10\ \mu$ longo, $2-3\ \mu$ crasso saepe proferentibus; his bullis vermiculos nematodeos tenentibus, integumentum perforantibus, tuber mortiferum saepe $8-10\ \mu$ crassum intrudentibus, hyphas $2-5\ \mu$ crassas evolventibus, quae carnem exhauriunt. Hyphae fertiles hyalinae, erectae, septatae, $100-200\ \mu$ altae, basi $2.5-4\ \mu$ crassae, sursum fastigatae, apice circa $1.5\ \mu$ crassae, plerumque simplices et unicum conidium ferentes, sed quandoque prope summum paululum ramosae tum 2 vel 3 conidia gerentes. Conidia hyalina, obconica vel clavata, basi truncata, apice rotundata, $20-46\ \mu$ (saepe circa

31.5 μ) longa, 6.5–9.5 μ (saepe circa 8.2 μ) crassa, 1–5 septata, fere 3-septata, loculo infimo tum saepe circa 8 μ longo, loculo antepaenultimo saepe circa 7.5 μ longo, loculo paenultimo saepe circa 9.8 μ longo, loculo summo saepe circa 6.2 μ longo.

Vermiculos nematodeos diversos pigros vulgo usque .3 mm. longos qui vulgo maximam partem specierum *Bunonematis* sunt capiens consumensque habitat exigue in humo silvestri sed abundius praecipue in glandibus quernis *Querci Prini* putrescentibus prope Beltsville, Maryland, et in Arlington, Virginia.

Mycelium spreading; composed of hyphae mostly 1.7 to 3 μ wide, that especially in the presence of nematodes give rise here and there, at angles approaching a right angle, to stalks 3 to 10 μ long and 2 to 3 μ wide, on each of which is borne a globose or prolate ellipsoidal unicellular adhesive knob, mostly 6.5 to 8 μ long and 6 to 7.5 μ wide; the knobs holding fast to nematodes, individually perforating their captive's integument, and intruding a globose mortiferous excrescence, often 8 to 10 μ in diameter, from which are extended lengthwise through the body assimilative hyphae, 2 to 5 μ wide, that appropriate the degenerating fleshy contents. Conidiophores hyaline, septate, erect, 100 to 200 μ , mostly 125 to 175 μ high, 2.5 to 4 μ wide at the base, tapering gradually upward to a width of approximately 1.5 μ , mostly unbranched and terminating in a single conidium, but occasionally giving off one or two branches some distance below the tip, and then bearing two or three conidia. Conidia hyaline, obconical or clavate, truncate at the narrow proximal end, broadly rounded at the distal end, 20 to 46 μ , mostly 26 to 36 μ (average 31.5 μ) long, 6.5 to 9.5 μ (average 8.2 μ) wide, containing 1 to 5 septa, but most often and most typically containing 3 septa, the basal of the 4 cells then delimited averaging about 8 μ in length, the antepenultimate cell about 7.5 μ , the penultimate cell about 9.8 μ , and the apical cell about 6.2 μ .

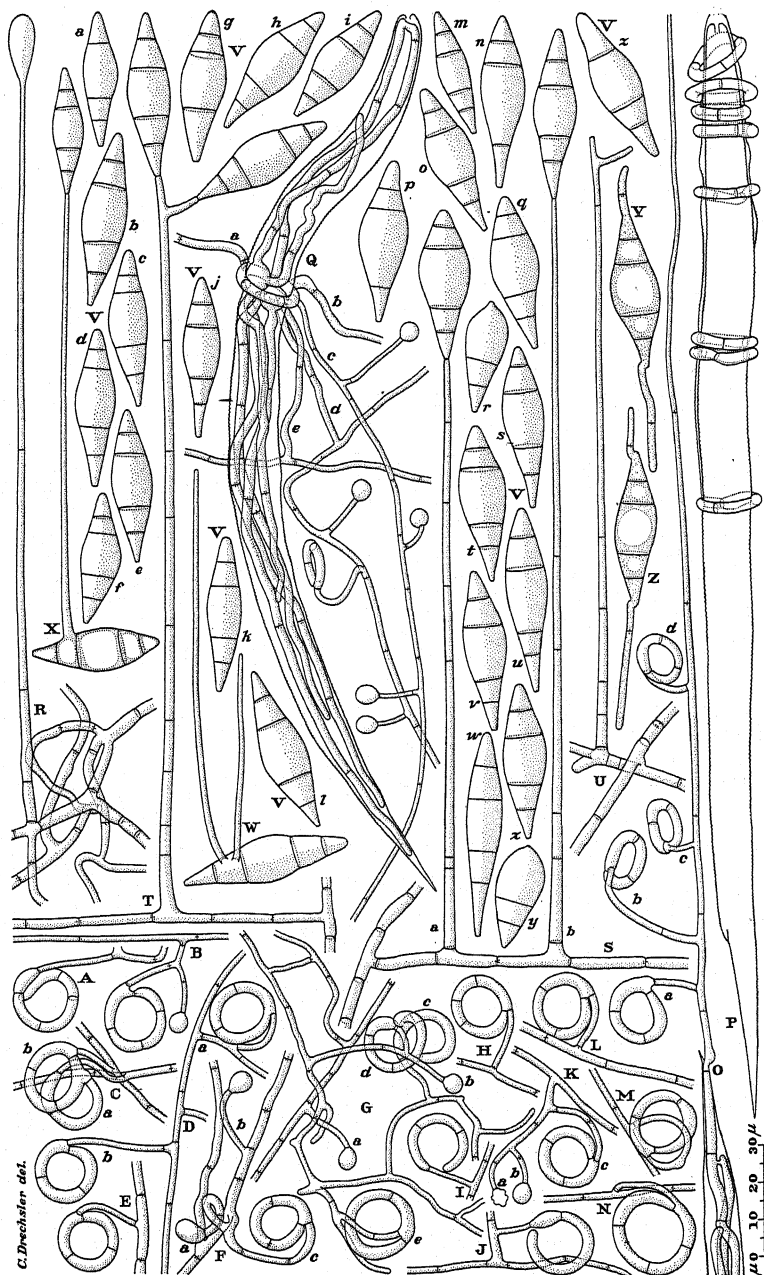
Capturing and consuming sluggish nematodes commonly up to .3 mm. in length, and for the most part belonging to species of *Bunonema*, it occurs sparingly in leaf mold but more abundantly within decaying acorns (*Quercus Prinus* L.) in Arlington, Va., and near Beltsville, Md.

DACTYLELLA LYSIPAGA

The fungus whose resemblance to *Dactylella ellipsospora* in morphology of reproductive structures has already been referred to, is easily distinguished from that species in cultures where its predacious apparatus has occasion to develop (FIG. 10, A-O). In part, to be sure, this apparatus consists of globose adhesive knobs

similar in design to the homologous organs formed in *D. ellipso-spora*, but differing from them in markedly smaller dimensions, as well as in their attachment to the parent filament by longish, slender, and often gracefully curved stalks, rather than on short, stout, straight ones. It would seem that in most agar substrata efficiency is associated more with size and sturdiness than with gracility; for the knobs of the present species have only rarely been found operative, and then only in the capture of larvae belonging to relatively lethargic nematodes. As was intimated earlier (15), the usual inefficiency of such knobs in a gelatinous culture medium need not preclude a greater degree of usefulness under the more different and varied physical conditions obtaining in natural substrata.

Development in nematode-infested agar cultures is made possible very largely through the more effective functioning of circular hyphal rings usually intermingled with the knobs, and like these produced terminally on short, slender, often gracefully circinate stalks. Nematodes ensnared in the rings are sometimes held in place, but more often they tear the encircling structure from its attachment and continue to move about, often only to be caught in a second ring, and occasionally even in a third. Accumulation of rings in larger numbers is perhaps somewhat infrequent in nature; yet as many as 8 have been seen encircling individual nematodes (FIG. 10, P) after large pieces of vigorous mycelium from pure cultures of the fungus on maize meal agar had been transferred to agar plate cultures abundantly infested with roundworms. Devoid of all predacious apparatus at the time of transfer, the mycelium soon gave rise to rings and adhesive knobs in spectacular concentration, thereby providing opportunity for more frequently repeated ensnarement of visiting eelworms. In spite of extraordinary concentration of hyphal rings an animal would assuredly not become ensnared more than a few times if the fungus were not somewhat dilatory in accomplishing the death of encircled specimens. Although in cellular make-up the rings are not without similarity to the strangulating organs of *Arthrobotrys dactyloides* and *Dactylella bembicodes*, they exert no active constriction; and the bulbous body slowly intruded into the animal after delayed penetration of its integument apparently never becomes large

FIG. 10. *Dactylella lysipaga*.

enough to kill or paralyze promptly. The decline of the animal is accordingly rather slow at first, but with the gradual extension of assimilative hyphae from the intruded bulb through the fleshy interior, movement gradually comes to an end. Appropriation of the degenerating materials makes possible further mycelial growth in the underlying or surrounding substratum; the additional hyphae arising for the most part from the outer surface of the ring itself (FIG. 10, *A*, *a-c*), though here and there an assimilative branch occasionally breaks through the integument to grow out directly as a mycelial filament (FIG. 10, *O*). Whatever their source, the new external hyphae in their turn give rise to predacious organs, thus renewing the vegetative cycle.

The conidiophores (FIG. 10, *R-U*) and conidia (FIG. 10, *V*, *a-s*) produced usually in rather meager quantity, whether on nematode-infested substrata or in pure culture, closely resemble the homologous structures of *Dactylella ellipsospora*, but show on the whole somewhat smaller dimensions throughout. Measurements of conidia from representative material give average values for length and width corresponding very well to the values given by Smith (65); so that, as has been mentioned previously, it seems probable that this author was dealing with the species under consideration rather than with the one described by Grove. A conidium, after falling on a slightly moist substratum, often thrusts up an erect conidiophore (FIG. 10, *X*) to bear a secondary conidium, somewhat smaller but otherwise like its parent. Occasionally two conidiophores may be pushed up from a fallen spore (FIG. 10, *W*). On wetter substrata germination takes place, as in *D. ellipsospora*, by the production of two polar germ tubes (FIG. 10, *Y*, *Z*).

The fungus seems closely related also to *Dactylaria candida*, presenting obvious resemblance to that species in type of predacious apparatus, as well as in shape and septation of conidium. However, a capitate arrangement of the spores has never been observed here, though occasionally a second conidium may be borne on a short spur attached some distance below the tip of the axial hypha (FIG. 10, *T*, *U*).

It is hoped that an epithet compounded of words meaning "a loosing" and "snare," may appropriately suggest the combination

of predacious and ectoparasitic relationships revealed by the species.

***Dactylella lysipaga* sp. nov.**

Mycelium effusum; hyphis hyalinis, septatis, $1.5\text{--}3.5\ \mu$ crassis, non modo bullas tenacis globosas vel ellipsoideas plerumque $5\text{--}8\ \mu$ longas, $4.5\text{--}6\ \mu$ latas, sed etiam laqueos circulares $13\text{--}23\ \mu$ latos in 2–3 plerumque 3 loculis subaequalibus, arcuatis, $2.5\text{--}4\ \mu$ crassis consistentes ex ramulo saepe aliquantum curvato vel decore circinato $5\text{--}35\ \mu$ longo, $1.2\text{--}2\ \mu$ crasso ferentibus; bullis vermiculos nematodeos tenentibus, integumentum perforantibus, hyphas intus evolventibus quae carnem exhauriunt; laqueis vermiculos nematodeos irretientibus, modo hos capientibus, modo ipsis avolsis, sed tamen integumentum semper perforantibus, hyphas intus evolventibus quae carnem exhauriunt. Hyphae fertiles hyalinae, erectae, septatae, $125\text{--}250\ \mu$ altae, basi $3\text{--}5\ \mu$ crassae, sursum fastigatae, apice $1.1\text{--}1.8\ \mu$ crassae, plerumque simplices et unicum conidium ferentes sed quandoque secundum conidium ex ramusculo prope apicem orto gerentes. Conidia hyalina, vulgo fusioidea, apice rotunda, basi truncata, $28\text{--}55\ \mu$ (saepe circa $40.7\ \mu$) longo, $9\text{--}14\ \mu$ (saepe circa $11.6\ \mu$) lata, subinde 2 vel 3 septata, saepius 4-septata, loculo infimo tum fere circa $8.2\ \mu$ longo, huic proximo superiore loculo fere circa $6.8\ \mu$ longo, loculo medio fere circa $13.8\ \mu$ longo, loculo paenultimo fere circa $6.1\ \mu$ longo, loculo summo fere circa $6.3\ \mu$ longo.

Vermiculos nematodeos graciles multarum specierum interficiens consumensque habitat in humo silvestri prope Beltsville, Maryland, et in Arlington, Virginia.

Mycelium spreading; the vegetative hyphae hyaline, septate, mostly 1.5 to $3.5\ \mu$ wide, often especially in the presence of nematodes, giving rise on slightly curved or circinate stalks 5 to $35\ \mu$ long, 1.2 to $2\ \mu$ wide and composed of one or more cells, either to adhesive unicellular knobs, subspherical or prolate ellipsoidal in shape, 5 to $8\ \mu$ in length and 4.5 to $6\ \mu$ in width, or to generally discrete, approximately circular rings, 13 to $23\ \mu$ in diameter, composed usually of 3, more rarely of 2 or 4 subequal, arcuate filamentous cells mostly 2.5 to $4\ \mu$ wide—the knobs capturing nematodes through adhesion, individually perforating the integument of each, and intruding assimilative hyphae; the rings after individually ensnaring nematodes sometimes remaining attached, but often being torn loose from their attachments, yet in either event likewise perforating the integument and intruding assimilative hyphae to appropriate the fleshy contents. Conidiophores hyaline, septate, erect, 125 to $250\ \mu$ high, 3 to $5\ \mu$ wide at the base, tapering upward to a width of 1.1 to $1.8\ \mu$, mostly simple and bearing a single terminal conidium but occasionally producing a second conidium on a short branch attached to the main axis some distance below the tip. Conidia hyaline, sometimes obovoid-fusoid, but much more frequently and more typically rather symmetrically

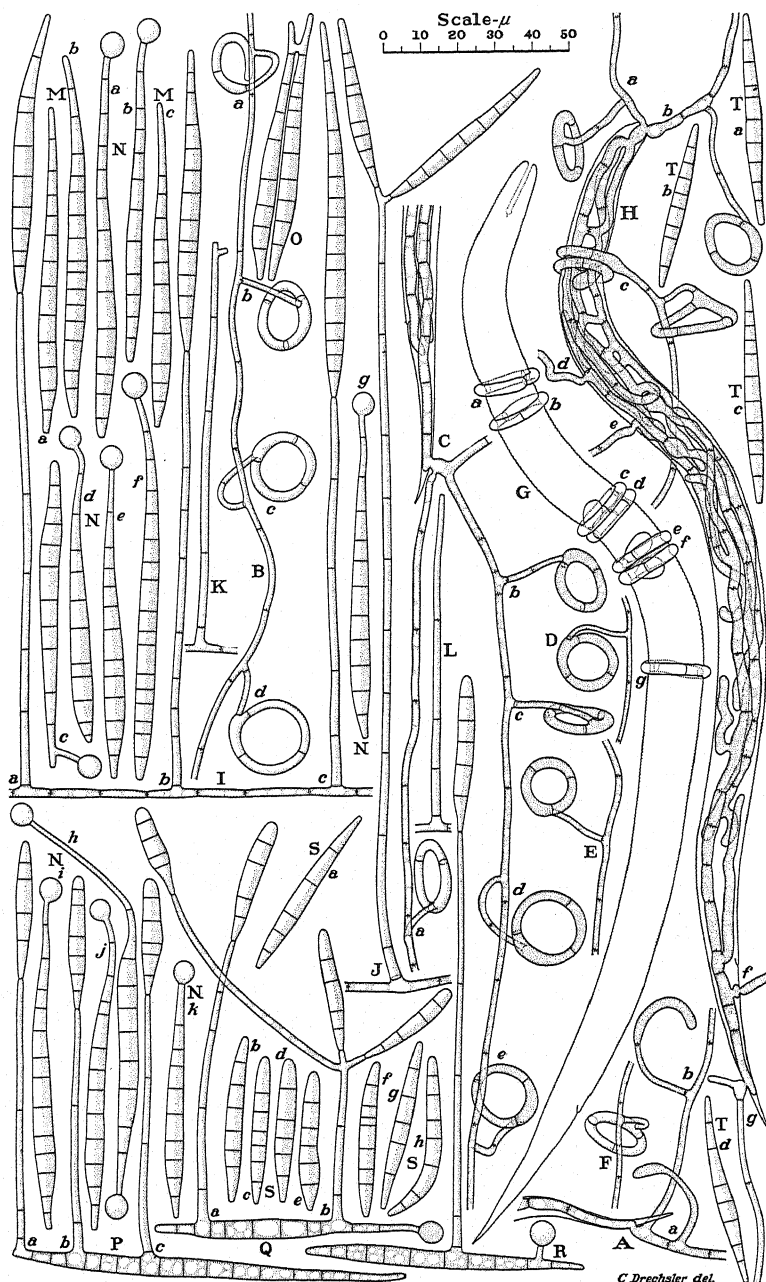
fusoid, somewhat acutely rounded at the apex, truncate at the narrow base, 28 to 55 μ (average 40.7 μ) long, 9 to 14 μ (average 11.6 μ) wide, sometimes 2- or 3-septate, but more frequently and typically divided by 4 cross-walls into 5 cells, whereof the basal one averages 8.2 μ in length, the one adjacent to the proximal cell 6.8 μ , the middle one 13.8 μ , the penultimate one 6.1 μ , and the apical one 6.3 μ .

Destructive to slender nematodes belonging often to the genera *Rhabditis* and *Plectus*, it occurs in leaf mold in deciduous woods near Beltsville, Md., and in Arlington, Va.

DACTYLELLA LEPTOSPORA

The somewhat *Fusarium*-like predacious fungus whose main structural features were briefly described in an earlier summary (14: p. 355, lines 28-40; p. 356, lines 1-4; p. 357, lines 7-14, fig. 16, A, B, C) has been found only a few times, and then always in nematode-infested agar plate cultures to which pinches of leaf mold had been added. On the rather delicate hyphae that make up the sparse mycelium in such cultures, it gives rise under the surface of the substratum to stalked non-constricting hyphal rings (FIG. 11, A-F) closely similar to those produced by *Dactylella lysipaga* both in morphology and manner of operation. When conditions are provided for an abundant production of these rings in cultures infested with nematodes, the animals are ensnared in impressive numbers, some accumulating more than a half dozen of the annular structures (FIG. 11, G) before the gradual extension of assimilative hyphae through the fleshy interior finally brings locomotion to a halt. Appropriation of the degenerating cellular materials is accomplished much as in the case of *D. lysipaga*. The accession of nourishment naturally leads to production of new mycelial hyphae, which here arise in noticeably smaller proportion from the ring, and in correspondingly greater proportion consist of branches that are put forth directly from assimilative hyphae to reach the exterior through perforations in the integument (FIG. 11, H).

In comparison to the fertile hyphae of most fungi predacious on nematodes, the conidiophores of the present species appear of somewhat small stature (FIG. 11, I, a-c; J-L). Even in the pres-

FIG. 11. *Dactylella leptospora*.

ence of an abundant supply of suitable animals they have never been seen produced in nematode-infested agar-plate cultures other than in meager quantity. However, in pure culture on maize meal agar, reproduction is usually much more copious; and results, moreover, in conspicuously larger conidia. Thus, measurements of a representative assortment of conidia from a nematode-infested agar culture (FIG. 11, *T, a-d*) gave averages of $53\ \mu$ and $4.6\ \mu$ for length and width respectively; whereas measurements of primary conidia from pure culture on maize meal agar (FIG. 11, *M, a-c*) gave corresponding averages of $73\ \mu$ and $5\ \mu$ respectively. Further variability in conidial dimensions is introduced through repetitional development, which especially in pure culture often takes place very abundantly (FIG. 11, *P-R*), some of the larger primary spores giving rise to two, three, or even four secondary ones. As might be expected under such circumstances, the secondary conidia are for the most part of decidedly smaller size (FIG. 11, *S, a-h*), measurements of specimens chosen at random giving averages of $36\ \mu$ and $4.8\ \mu$ for length and width respectively.

Aside from repetitional development and frequent vegetative fusions (FIG. 11, *O*), conidia produced in pure culture on maize meal agar often show numerous globose cells, closely similar and undoubtedly homologous to the adhesive knobs in *Dactylella lysipaga*. Very often these globose cells are formed singly on the individual spore, either on a narrow apical prolongation (FIG. 11, *N, a-g, i-k*), or less commonly on a lateral stalk (FIG. 11, *R*); yet specimens with two such structures (FIG. 11, *N, h*) are not at all rare. That these cells represent predacious organs can hardly be questioned; though it must be admitted that so far they have been observed only a few times on mycelium in nematode-infested agar cultures, and then were never seen operative in taking prey.

In morphology of reproductive apparatus the fungus invites comparison more especially with three of the various species producing elongate conidia that have been compiled in the genera *Monacrosporium* and *Dactylella*, namely: *M. subtile* Oud. (52) with elongate clavate conidia, 45 to $70\ \mu$ long, 5 to $7\ \mu$ wide, and divided by septa up to 13 in number; *M. oxysporum* (61), with conidia 96 to $105\ \mu$ long, 9 to $10.5\ \mu$ wide, and divided by 10 to 12 cross-walls; and *D. minuta* var. *fusiformis* (28) with conidia

60 to 75 μ long, 7 to 9 μ wide, and containing 9 to 12 partitions. As the species mentioned were all described from substrata favorable for the development of microscopic animal life, the possibility of their occurrence in predacious relationships is not to be denied; and certainly the morphology of their reproductive apparatus strongly suggests true membership in the predacious series. Despite an approximate agreement in spore dimensions, the nematode-capturing fungus under consideration can not well be referred to *M. subtile*, since its conidia, when departing from a symmetrically fusiform shape, are much more inclined to become obclavate than clavate. Nor can assignment be made either to *M. oxysporum* or to *D. minuta* var. *fusiformis*, as the ranges for width of conidium given for these species lie beyond any values for this dimension attained in my fungus. Although the shorter, less frequently septate, and more pronouncedly *Fusarium*-like conidia of *D. passalopaga* are of equally small diameter, an epithet compounded in part of a word meaning "slender" may help to set off the species in question from the two other forms that employ non-constricting rings in the destruction of nematodes.

Dactylella leptospora sp. nov.

Mycelium effusum; hyphis septatis, hyalinis, vulgo 1.2–3 μ raro usque 4 μ crassis, laqueos circulares 13–22 μ latos in 3 loculis subaequalibus arcuatis 2.3–4.5 μ crassis vulgo consistentes ex ramulo primo paulum curvato vel decore circinato 10–35 μ longo, 1.2–2 μ crasso ferentibus, raro bullas globosas vel ellipsoideas 6–7 μ longas, 5.5–6.8 crassas ex ramulo recto vel leviter curvato 3–35 μ longo, circa 1.5 μ crasso evolventibus—laqueis vermiculos nematodeos irretientibus, modo hos capientibus modo ipsis avolsis, sed tamen semper integumentum perforantibus, tuber bursiforme debilitans 7–10 μ longum 5–6 μ latum intrudentibus, hyphas intus evolventibus quae carnem exhauriunt. Hyphae fertiles hyalinae, septatae, erectae, 75–225 μ altae, basi 2.5–3.5 μ crassae, sursum paulo fastigatae, apice 1.3–2 μ crassae, fere simplices et unicum conidium ferentes sed quandoque secundum conidium ex ramusculo prope apicem orto gerentes. Conidia ordinis primi hyalina, fere recta, elongato-fusoides vel cylindracea, 40–105 μ longa, 4–5.8 μ crassa, 5–15 septata; interdum bullas tenacis globosas proferentibus, interdum ex hyphis ferilibus germinationis erectis, septatis, simplicibus vel paulo ramosis, 50–125 μ longis, basi 2–3 μ apice 1.3–1.8 μ crassis, conidia ordinis secundi vulgo 25–50 μ longa, 4–5.8 μ crassa, 3–8-septata ferentia.

Vermiculos nematodeos graciles multarum specierum interficiens consumensque habitat in humo silvestri prope Beltsville, Maryland, et in Arlington, Virginia.

Mycelium spreading; the vegetative hyphae hyaline, septate, mostly 1.2 to 3 μ , rarely up to 4 μ wide, often, especially in the presence of nematodes, giving rise here and there on stalks frequently curved or circinate, 10 to 35 μ long and 1.2 to 2 μ wide, to generally discrete, approximately circular rings measuring 13 to 22 μ in diameter and composed of subequal arcuate cells, usually 3 in number and 2.3 to 4.5 μ in width; much less frequently giving rise on stalks 3 to 35 μ long and 1.5 μ wide to unicellular knobs, subspherical or prolate ellipsoidal in shape, 6 to 7 μ long and 5.5 to 6.8 μ wide: the rings after individually ensnaring a nematode, sometimes remaining attached, but very often, too, being torn loose from their attachments—in either case perforating the integument, intruding a bursiform excrescence 7 to 10 μ long and 5 to 6 μ wide, and therefrom extending assimilative hyphae lengthwise through the body to appropriate the fleshy contents. Primary conidiophores hyaline, erect, septate, 75 to 225 μ high, 2.5 to 3.5 μ wide at the base, tapering upward very slightly, 1.3 to 2 μ wide at the tip, mostly simple and bearing a single terminal conidium, but occasionally bearing an additional conidium on a short branch attached to the main axis near its apex. Primary conidia hyaline, mostly straight, elongate fusoid or cylindrical, 40 to 105 μ long, 4 to 5.8 μ wide, divided by 5 to 15 cross-walls,—after falling off, often giving rise individually to 1 or 2 globose knobs mostly on scarcely modified distal prolongations, more rarely on lateral stalks; often, too, producing on slightly branched conidiophores, 50 to 125 μ long, 2 to 3 μ wide at the base and 1.3 to 1.8 μ wide at the tip, secondary conidia mostly 25 to 50 μ long, 4 to 5.8 μ wide, and divided by 3 to 8 cross-walls.

Destructive to slender nematodes belonging often to the genera *Rhabditis* and *Plectus*, it occurs in leaf mold in deciduous woods near Beltsville, Md., and in Arlington, Va.

DACTYLELLA GEPHYROPAGA

The fungus with rectangular predacious meshes that was briefly described in an earlier summary (13: p. 268, lines 3–24; p. 269, fig. 12, A–C), has made its appearance frequently in nematode-infested agar-plate cultures following the addition of leaf mold from several widely separated localities in Iowa, Wisconsin, Maryland and Virginia. Its presence in such cultures is first made known through the production of perpendicular columnar processes

at rather close intervals on the straightforward, sparsely distributed superficial mycelial hyphae (FIG. 12, *A*). These processes though resembling the predacious organs of *Dactylella ellipsospora* in stature and often also in number of component cells, show no constant differentiation into innocuous stalk and expanded adhesive knob, but seem, instead, to be of approximately equal width and adhesiveness from base to rounded apex. Moreover, while the stalked knobs of *D. ellipsospora* are largely formed immersed in the agar substratum, the columnar processes of the present species are commonly developed on the surface, usually, indeed, being thrust vertically into the air, sometimes, it is true, only to be brought down into prostrate positions through the violence of captured nematodes.

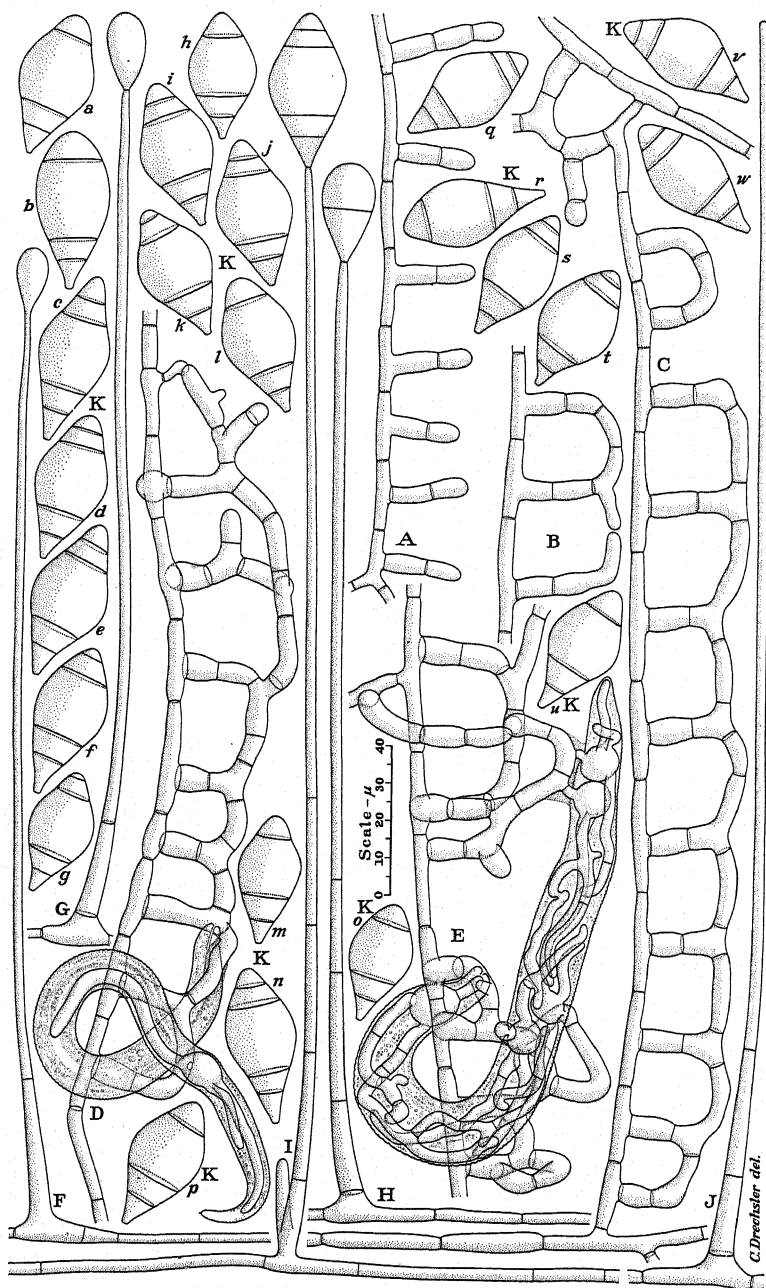
After attaining a length mostly of about 20μ , the columnar processes abruptly change their direction of growth so that further elongation takes place along an axis parallel to the parent filament, and toward the apex of a neighboring process. When this apex is reached, as also when two elements growing directly toward one another meet midway in the manner of a bridge (FIG. 12, *B*), anastomosis occurs and a rectangular mesh is formed. Conjunction frequently of closely spaced columnar processes in a continuous series of rectangular meshes results in a scalariform network extended usually in one plane (FIG. 12, *C*), which provides the most characteristic morphological feature of the species. The scalariform arrangement may later be partly obliterated through the production of a new series of columnar processes, followed by the superimposition of additional hyphal meshes often in other planes than the primary meshes and with little of their regular arrangement (FIG. 18, *D*, *E*).

Capture of nematodes is accomplished, as in other retiary species, through adhesion combined often with entanglement (FIG. 12, *D*). The columnar processes, which manifestly can operate only by adhesion, serve mainly in holding the younger and less vigorous animals; though their close, bristling arrangement facilitates multiple contact and thereby adds much to their effectiveness. Entanglement in closed meshes appears of importance chiefly in the capture of the larger and stronger eelworms. Whether the predacious unit engaged be one type or the other, it narrowly perfor-

ates the integument, and paralyzes the nematode by intruding a bulbous excrescence, from which assimilative hyphae are extended lengthwise through the inert body to appropriate the degenerating fleshy contents (FIG. 12, *E*).

In addition to nematodes, the fungus occasionally captures individuals of *Trinema enchelys* Ehrenb. found in agar cultures prepared with decaying vegetable material. Apparently the rhizopod in feeding is caught by its mouth on an adhesive columnar process, which then grows into the protoplasmic interior (FIG. 18, *M*). A yellow coloring substance is secreted around the invading filament, much as around filaments of *Dactylella tylopaga* invading specimens of *Amoeba verrucosa* Ehrenb. The predacious relationship here seems more or less incidental in the life of the species, yet offers more than negligible interest in illustrating an underlying character of the series. Apparently likewise representative of traits better developed in allied forms are the occasional instances that came under observation, wherein oöspores of *Pythium Butleri* Subr. were penetrated, invaded and successfully parasitized by lateral branches from submerged hyphae of the fungus.

The sturdy conidiophores (FIG. 12, *F-J*) that arise somewhat sparsely from the rangy hyphae in nematode-infested agar cultures, and in greater abundance from the fairly dense mycelium produced when the fungus is grown in pure culture on maize meal agar, rather closely resemble those of *Dactylella bembicodes*. Similarly the conidia (FIG. 12, *K, a-w*) borne on them closely resemble the conidia of *D. bembicodes* in size and shape, though presenting a difference often useful for purposes of identification in that they commonly show a 4-septate condition coördinate with a 3-septate condition. The numerical proportion between the spores containing three cross-walls and those containing four is subject to considerable variation. In the 100 specimens whose measurements were used to obtain the relevant dimensional data submitted in the diagnosis below, 61 contained four partitions, 35 contained three partitions, and 4, possibly not all fully mature, contained two partitions. All of the 4-septate specimens had their partitions so spaced that two small cells were delimited at each of the ends leaving a relatively massive ventricose cell in the middle. Of the 3-septate conidia, 33 showed the ventricose cell in penulti-



mate position between two small proximal cells and a single small distal cell; while the remaining two showed the ventricose cell in antepenultimate position, between a small basal segment and two small distal segments. As might be expected, the more abundantly septate conidia were slightly larger than those with fewer partitions, the 61 specimens with four cross-walls giving an average length of 39.5μ , as contrasted with an average length of 38.2μ for the random assortment. Without reference to septation, the 100 measurements gave a distribution of values for length, expressed to the nearest micron as follows: 27μ , 1; 33μ , 6; 34μ , 8; 35μ , 3; 36μ , 7; 37μ , 9; 38μ , 19; 39μ , 12; 40μ , 11; 41μ , 12; 42μ , 4; 43μ , 4; 44μ , 3; 46μ , 1; and a distribution of values for width as follows: 16μ , 3; 17μ , 7; 18μ , 31; 19μ , 32; 20μ , 23; 21μ , 4.

From *Monacrosporium elegans* the fungus is separated not only like *Dactylella bembicodes* by the smaller dimensions of its conidia, but also by their frequently 4-septate condition. On the other hand, the generous admixture of spores with no more than three cross-walls makes it ineligible for identification with *D. ellipsospora*, especially when considered in opposition to the more regularly 4-septate knobbed form treated herein under Grove's binomial. It is therefore described as a new species under a name compounded of two words meaning "bridge" and "trap" respectively.

***Dactylella gephyropaga* sp. nov.**

Mycelium effusum; hyphis hyalinis, septatis, $2-5 \mu$ crassis, ramulos glutinosos columnares $10-30 \mu$ saepe circa 20μ longos, $4-7 \mu$ crassos, ex 1-3 cellulis compositos, inter se $20-30 \mu$ distantes emittentibus; his ramulis diende subito recta hyphae originis regione saepe crescentibus, incrementis vicinis inter se ad instar ponticuli conjungentibus, ita laqueos quadrilateros modo separatos modo in rete mirabiliter scaliforme connectos textentibus; haerendo irretiendoque ramulis columnaribus et laqueis quadrilateris vermiculos nematodeos capientibus, integumentum perforantibus, tuber mortiferum intrudentibus, hyphas intus evolventibus quae carnem exhaustiunt; atque alia animalia subinde tenentibus et carnem eorum assumuntibus. Hyphae fertiles hyalinae, erectae, septatae, $225-500 \mu$ altae, basi $5-7.5 \mu$ crassae, sursum leviter fastigatae, propter apicem perspicuius attenuatae, ibi $1.5-2.7 \mu$ crassae, unicum conidium ferentes. Conidia hyalina, turbinea, $27-46 \mu$ (saepe circa 38.2μ) longa, $16-21 \mu$ (saepe circa 18.7μ) lata, raro 2-septata, plerumque 3- vel 4-septata, quandoque 4-septata cellula infima obconica circa 7μ longa, huic proxima superiore cellula disciformi ad 6.2μ

longa, cellula antepaenultima dolioformi vel ventricosa circa 17.6μ longa, cellula paenultima disciformi circa 4.7μ longa, cellula summa apice rotundata circa 4μ longa.

Vermiculos nematodeos multarum specierum vulgo usque .6 mm. longos, subinde *Trinema enchelyn* capiens consumensque habitat in materiis plantarum putrescentibus et in humo silvestri prope Madison, Wisconsin; Ames, Iowa; Cumberland et Beltsville, Maryland; in Arlington, Virginia.

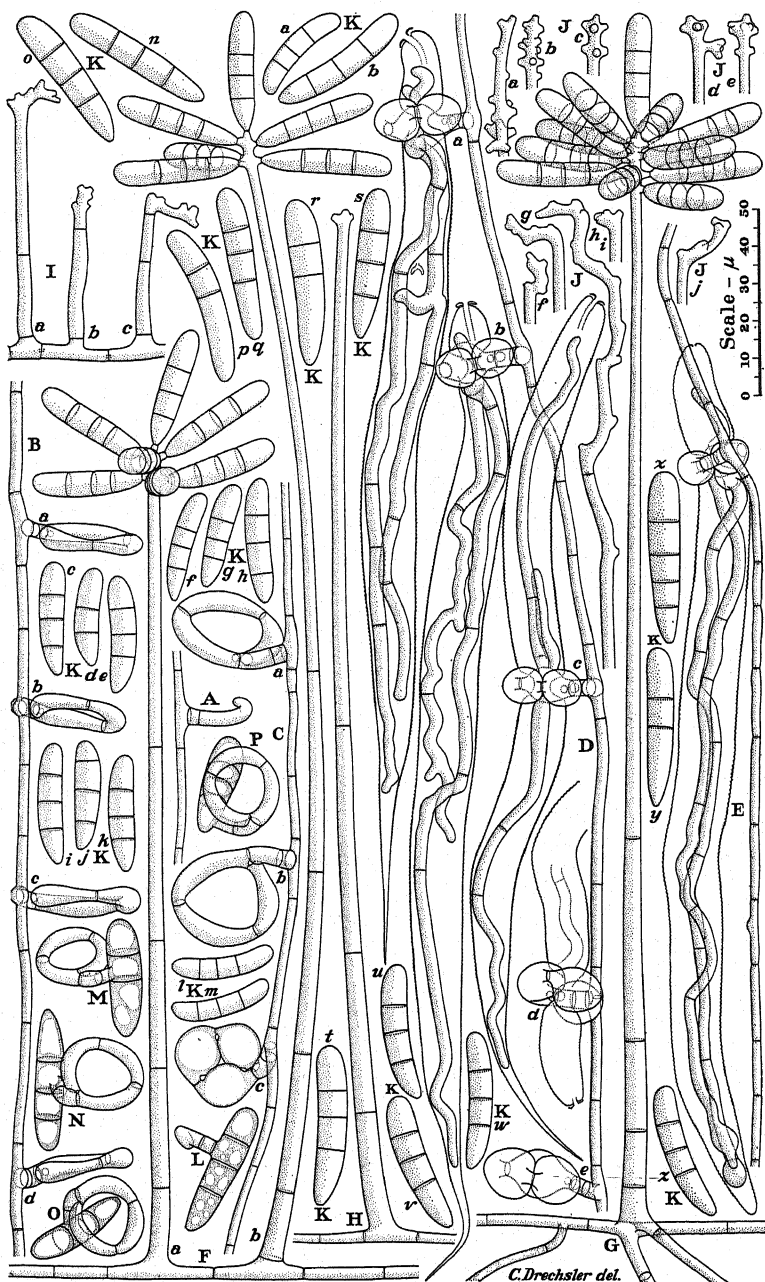
Mycelium spreading; the vegetative hyphae hyaline, septate, mostly 2 to 5μ wide, often, especially in the presence of nematodes giving rise at intervals frequently of 20 to 30μ , to adhesive columnar branches 10 to 30μ long and 4 to 7μ wide that consist generally of 2, less often of 1 or 3 cells—these branches later often abruptly changing their direction of elongation to grow parallel to the parent filament, the increments anastomosing with the neighboring branches, or with the similar increments put forth by the latter to form quadrilateral meshes, sometimes discrete but frequently compounded into scalariform networks of variable lengths, wherefrom adhesive columnar processes may be produced in turn; the columnar processes, meshes and networks capturing nematodes by adhesion and entanglement, then perforating the integument of each animal, and intruding a mortiferous excrescence that gives rise to assimilative hyphae which grow lengthwise through the body and appropriate the fleshy materials,—occasionally, also, capturing other animals to utilize their contents. Conidiophores hyaline, erect, septate, 225 to 500μ high, 5 to 7.5μ wide at the base, tapering gradually upward to within about 10μ from the apex, from thence narrowing somewhat more markedly to a width of 1.5 to 2.7μ at the tip whereon is borne usually a single conidium. Conidia hyaline, handsomely top-shaped, broadly rounded at the distal end, tapering toward the slightly protruded truncate base, 27 to 46μ (average 38.2μ) long, 16 to 21μ (average 18.7μ) wide, rarely 2-septate, commonly 3-septate and 4-septate; when 4-septate, the basal obconical cell averaging about 7μ in length, the second and disciform cell about 6.2μ , the central barrel-shaped or ventricose cell about 17.6μ , the penultimate cell about 4.7μ , the apical cell about 4μ .

Capturing and consuming nematodes commonly up to .6 mm. in length, belonging to many species of *Acrobeles*, *Acrobeloides*, *Cephalobus*, *Diplogaster*, *Diploscapter*, *Plectus* and *Rhabditis*, and sometimes capturing also specimens of *Trinema enchelys*, it occurs in decaying vegetable materials and in leaf mold near Madison, Wis., Ames, Ia., Cumberland, Md., and Beltsville, Md., and in Arlington, Va.

DACTYLARIA BROCHOPAGA

The fungus bearing 3-septate cylindrical conidia in loose capitate arrangement, to which reference was made in an earlier summary (13: p. 268, lines 32-36; p. 269, fig. 14, A-C; p. 270, lines 1-6), has appeared occasionally in nematode-infested agar plate cultures following the addition of small quantities of leaf mold. In such cultures its straightforward vegetative hyphae bear at intervals stalked constricting rings (FIG. 13, A-C) that in manner of development as well as in shape, structure, and mode of operation, are indistinguishable from the predacious organs of *Arthrobotrys dactyloides* and *Dactylella bembicodes*. The assimilative hyphae extended through a captured nematode after the ring has squeezed it into a state of relative immobility, generally show no terminal modification in sharp-tailed animals (FIG. 13, D), but in blunt-tailed prey become distended at the tip (FIG. 13, E) like the haustorial filaments of *A. dactyloides*.

With ample nourishment the rather sparse mycelium in nematode-infested agar plate cultures gives rise to a scattering of erect fertile hyphae that terminate individually in a handsome radiating head containing mostly about a half dozen conidia (FIG. 13, F, a, b; G). The capitate arrangement of the multiseptate spores conforms to the reproductive habit specified in the phragmosporous Mucedinaceae for the genus *Dactylaria*, though the stubby sterigmata on which the conidia are borne appear to be broader and usually more distinctly separated from one another (FIG. 13, H, J, a-e) than would seem implied in the descriptions of most recognized members of this genus. In pure culture on maize meal agar, where the fungus gives rise to lustrous, radiating, and rather dense mycelial growth, spores are sometimes borne on relatively short conidiophores (FIG. 13, I, a-c); and their arrangement may reveal all gradations between typically capitate and loosely racemose extremes (FIG. 13, J, f-j). In pure culture, too, the conidia exhibit somewhat more variability in size, shape and septation; though here, as also on wormy substrata, variations related to differences in cultural conditions can usually be distinguished from analogous variations referable to underlying differences between separate strains. The disparity in size evident between the as-

FIG. 13. *Dactylaria brochopaga*.

sortment of smallish spores shown in figure 13, *K*, *a-m* on the one hand, and the assortment of largish spores shown in figure 13, *K*, *n-z* on the other, is illustrative of a dimensional difference between two strains that has remained recognizable under varied conditions of culture.

Not infrequently conidia germinate by giving rise to predacious rings, often of smaller size but otherwise resembling those borne on mycelial filaments (FIG. 13, *L-P*). A nematode ensnared in such a ring continues to move about for some time, being impeded slightly, to be sure, by the conidium buckled absurdly to its side. With constriction becoming steadily more severe, its movements gradually slacken and finally come to a halt; whereupon extension of hyphae lengthwise through the paralyzed body and assimilation of the fleshy contents follow much as in captured specimens.

Both in pure and in nematode-infested cultures, the fungus, as has been intimated previously, shows a general parallelism with *Arthrobotrys dactyloides*; so that the more abundant septation of its conidia, because of which it needs to be referred to a different genus, provides at the same time the feature most decisively distinguishing it as a species. *Dactylaria echinophila* Massal., possibly to be reckoned among the members of the predacious series, offers similarity with respect to number of cross-walls in the conidium, but the dimensions given by Saccardo, $16-26 \times 4-5 \mu$, would seem to indicate a definitely smaller fungus. Certainly the plant with conidiophores 25μ high and conidia measuring $17-22 \times 3.2-3.5 \mu$, that Rostrup (59) perhaps correctly listed under Massalongo's binomial, appears too small to be identified with the present species; and judging from the figure given by the Danish mycologist, differs besides in the delicate attachment and equidistant septation of its spores. *D. orchidis* Cooke & Mass. with 3-septate conidia 40 to 50μ long and 7 to 9μ wide, differs markedly in the much greater width, 10 to 12μ , and orange coloration of its conidiophores. The dilute purple color tinging the reproductive parts of *D. purpurella* (Sacc.) Sacc., appears alien not only to the present species, but to the predacious series generally. Other congeneric forms likewise present quite decisive differences from the fungus under consideration: *D. acicularis* Rostrup (59) in the awl-like shape of its narrow conidia; *D. mucronulata* Ell. &

Langl. in its much smaller conidial dimensions— $8-10 \times 2.5-3 \mu$; and *D. pulchra* Linder (39) as well as *D. oogena* (Mont.) Sacc. in its more abundant conidial septation.

The species is therefore described as new under a name compounded of two words meaning “noose” and “snare” respectively.

***Dactylella brochopaga* sp. nov.**

Mycelium effusum; hyphis hyalinis, septatis, $1.7-4.5 \mu$ crassis, laqueos circulares $20-35 \mu$ latos, in 3 cellulis arcuatis plerumque $14-28 \mu$ longis medio $4-7 \mu$ extremo $2.5-6 \mu$ crassis consistentes, ex ramulo biloculari $7-13 \mu$ longo, $3.5-6 \mu$ crasso proferentibus; his laqueis vermiculos nematodeos illaquentibus, deinde tum per contractionem inflationemque trium loculorum animalia magnopere comprimentibus, ita haec interficientibus, statim integumentum perforantibus et hyphas intus evolventibus quae carnem exhauriunt. Hyphae fertiles hyalinae, septatae, erectae, $40-400 \mu$ saepe $200-325 \mu$ altae, basi $4-7 \mu$ crassae, sursum leviter fastigatae, apice $2.4-3.5 \mu$ crassae, ibi ex sterigmatibus brevibus obtusis $2-12$ saepius $3-8$ conidia in capitulum pulchrum radians aggregata ferentes vel subinde usque 15 conidia in parte superiore rarius digesta gerentes. Conidia recta vel curvata, cylindracea vel elongato-ellipsoidea, apice rotundata, basin versus paulo attenuata, $26-46 \mu$ longa, $5-9 \mu$ crassa, $2-4$ septata, plerumque tribus septis in 4 loculos divisa, loculis infimo et apicali tum fere inter se subaequalibus sed aliquanto longioribus quam loculis antepaenultimo et paenultimo qui inter se etiam aequales sunt.

Vermiculos nematodeos multarum specierum vulgo usque $.6$ mm. longos laqueans consumensque habitat in humo silvestri prope Cumberland, Maryland, et in Arlington, Virginia.

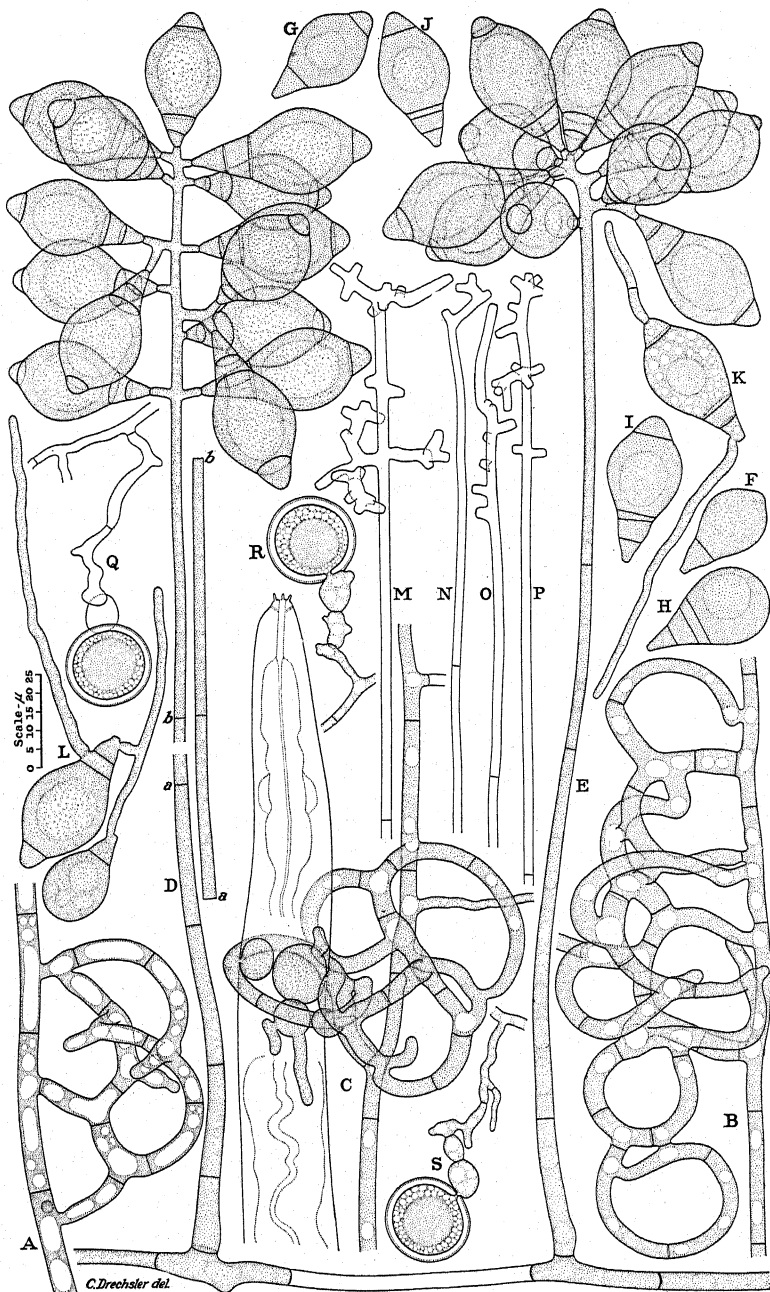
Mycelium spreading; the vegetative hyphae hyaline, septate, 1.7 to 4.5μ wide, often especially in the presence of nematodes producing underneath and at right angles to their axes approximately circular rings 20 to 35μ in outside diameter, composed individually of 3 arcuate cells 14 to 28μ long, 4 to 7μ wide in the middle and 2.5 to 6μ wide at the ends—the first and third of the cells being united usually to one another as well as to the distal end of the slightly curved supporting branch 7 to 13μ long, 3.5 to 6μ wide, and consisting mostly of 2 cells whereof the basal one is usually the shorter; after ensnarement of a nematode, the individual ring through contraction and inflation of its component arcuate cells constricting the animal to death or into a state of reduced activity preceding death, then perforating the integument and extending assimilative hyphae lengthwise through the interior to appropriate the fleshy contents. Conidiophores hyaline, septate, erect, 40 to 400μ , more typically 200 to 325μ high, 4 to 7μ wide at the base, tapering gradually upward to a width of 2.4 to 3.5μ near the tip, there bearing on short blunt sterigmata 2 to 12 , mostly 3 to 8 co-

nidia in beautiful radiating capitate arrangement—or less often and less typically producing up to 15 conidia in more scattered, irregularly racemose arrangement. Conidia hyaline, straight or slightly curved, cylindrical or elongate ellipsoidal, broadly rounded at the apex, usually tapering noticeably toward the somewhat truncate base, 26 to 46 μ long, 5 to 9 μ wide and containing 2 to 4 cross-walls, though most frequently divided by 3 septa into 4 cells—the basal and apical cells then approximately equaling one another in size, but exceeding in length by a third or even a half the antepenultimate and penultimate cells, which also are approximately equal to one another.

Ensnaring and consuming nematodes commonly up to .6 mm. in length, belonging to many species of *Acrobeles*, *Acrobeloides*, *Cephalobus*, *Diplogaster*, *Diploscapter*, *Plectus*, *Rhabditis* and *Mononchus*, it occurs in leaf mold in deciduous woods near Cumberland, Md., and in Arlington, Va.

DACTYLARIA THAUMASIA

The fungus whose production of 3-septate obovoid conidia in loose heads was referred to in an earlier summary (12: p. 139, 7, 8, 18–20, fig. 5, A, D) occurs widely in decaying plant remains. After having been first obtained in old isolation agar plate cultures planted with decaying rootlets of spinach, it has frequently made its appearance in nematode-infested cultures following addition of leaf mold from supplies of this materials collected as opportunity offered in deciduous woods in several widely separated localities. Often, especially under moist conditions, when the surface of the substratum is lubricated with bacterial slime in a manner greatly reducing the effective leverage of nematodes, it destroys these animals in such large numbers that here and there accumulations of their remains become plainly visible to the naked eye as scabby deposits. The apparatus through which this destruction is accomplished, closely resembles that of *Arthrobotrys oligospora* and *A. conoides*, similarly consisting of rather wide hyphal bails and loops, which at first are discrete but later usually become compounded into more or less extensive reticula (FIG. 14, A, B). Capture is brought about through adhesion combined frequently, especially under drier conditions, with physical entanglement. It promptly leads to perforation of the animal's integument, intrusion of one

FIG. 14. *Dactylaria thaumasia*.

or more globose structures, and extension of assimilative filaments lengthwise within the paralyzed body precisely as in other retiary species (FIG. 14, C).

In the beginning the conidiophores arising at intervals from the straightforward vegetative filaments that make up the sparse mycelium of the fungus in nematode-infested cultures, might easily be mistaken for fertile hyphae of *Dactylella bembicodes* and *D. gephyropaga*, which they closely resemble in stature and in production of large obovoid conidia. With an ample supply of eelworms to provide continued nourishment, a distinctive difference soon becomes evident in that additional conidia are developed by the individual sporophores, either on terminal prolongations or on rather broad stubby sterigmata that project at wide angles from the distal portion of the axis. Though on wormy substrata the spores borne on a sporophore ordinarily do not exceed three or four in number, their arrangement in terminal heads makes for a handsome appearance under a microscope of low magnification. Even more impressive reproductive apparatus is obtained in pure culture on maize meal agar if the fungus is permitted to continue development for several weeks by being protected against early desiccation of the medium. Very often about a dozen (FIG. 14, D, E) and sometimes more than a score of conidia may then be found in beautiful capitate clusters held aloft on tall conidiophores. In very copiously laden conidial apparatus the sterigmata are frequently borne in large part on short lateral branches (FIG. 14, M), whereas in apparatus more moderately prolific the sterigmata arise mainly from the axis itself (FIG. 14, N-P).

The conidia closely resemble those of *Dactylella bembicodes* and *D. gephyropaga* not only in shape but also in size. A somewhat greater variability in dimensions is usually apparent here, the 100 presumably representative conidial measurements from which were obtained the relevant metric data submitted in the diagnosis below, giving a distribution of values for length expressed to the nearest micron, as follows: 27 μ , 1; 28 μ , 1; 30 μ , 5; 31 μ , 5; 32 μ , 5; 33 μ , 5; 34 μ , 11; 35 μ , 10; 36 μ , 13; 37 μ , 4; 38 μ , 7; 39 μ , 5; 40 μ , 7; 41 μ , 5; 42 μ , 5; 43 μ , 3; 45 μ , 1; 46 μ , 3; 47 μ , 2; 48 μ , 1; 49 μ , 1; and a distribution of values for width as follows: 15 μ , 1; 16 μ , 3; 17 μ , 12; 18 μ , 19; 19 μ , 20; 20 μ , 19; 21 μ , 14; 22 μ , 9;

23 μ , 3. Of the 100 conidia, which were taken at random in equal numbers from maize meal agar plate cultures of four separate strains, 4, probably somewhat immature, contained one septum delimiting a small basal cell from a large distal one (FIG. 14, *F*); 17 contained two septa, which, except in one specimen with two small proximal cells below a large distal cell, delimited a small basal and a small apical segment from a large central segment (FIG. 14, *G*; FIG. 18, *L*, *b-e*) much as in the atypical biseptate swollen spores of *Arthrotrrys dactyloides* (FIG. 18, *K*, *d-f*, *i*, *j*, *l*, *m*, *n*, *p*); 77 contained three septa which, except in one specimen with three small proximal cells below a large distal cell (FIG. 14, *H*), delimited, after the manner usual in *D. bembicodes*, a small basal, a small antepenultimate, a large penultimate, and a small apical cell (FIG. 14, *D*, *E*; FIG. 18, *L*, *a*); and 2 contained four cross-walls, these partitions in one specimen being spaced symmetrically after the manner usual in *D. ellipsospora* to delimit two small proximal cells below and two small distal cells above a large middle cell, while the other specimen showed an arrangement of three small proximal segments, a large penultimate and a small apical segment (FIG. 14, *I*, *J*; FIG. 18, *L*, *f*).

Like the three larger retiary species of *Arthrotrrys*, the fungus produces yellow thick-walled chlamydospores (FIG. 14, *Q-S*) within the substratum. In pure culture on maize meal agar these bodies are sometimes formed in numbers so large that the substratum is given a perceptibly rusty color. When examined under a microscope of high magnification, two layers can usually be recognized in the enveloping wall, though perhaps more from differences in transparency than from spatial separateness.

Since on decaying natural materials with meager nematode infestation its poorly nourished conidiophores often give rise to only a single conidium, or at most to two or three conidia, the fungus obviously can not always be reliably distinguished on natural opaque substrata from *Dactylella bembicodes* or from *D. gephyropaga*. Positive identification of the species accordingly requires either cultivation on some transparent nematode-infested substratum to reveal its predacious apparatus, or somewhat prolonged development in pure culture under favorable conditions to bring to light its distinctive capitate reproductive habit. From *Monacro-*

sporium elegans it is separated not alone by its capitate habit, but also, like *D. bembicodes* and *D. gephyropaga*, by its definitely shorter conidia. *M. megasporum*, presumably, too, a closely related member of the predacious series, and in any case a truly capitate form, appears (4) no less clearly distinct from the present species by virtue of larger conidial dimensions, $35\text{--}57.5\ \mu \times 15.5\text{--}27.5\ \mu$, an ellipsoid rather than turbinate shape of its conidia, and the small size of the warty spore-bearing protuberances that beset the slightly enlarged tip of the sporophore somewhat as in *Arthrobotrys dactyloides*.

As the fungus under consideration evidently is different from any hitherto named in the literature, its description as a new species seems justified. The frequently spectacular appearance of its conidial apparatus suggests employment of a word meaning "wonderful" as a suitably expressive specific epithet.

***Dactylaria thaumasia* sp. nov.**

Mycelium effusum; hyphis hyalinis, septatis, plerumque $2\text{--}8\ \mu$ crassis, laqueos tenaces arcuatos vel circulares in reticula fere conjunctos saepe evolventibus; his laqueis vermiculos nematodeos illaqueantibus, deinde tum integumentum perforantibus, tuber mortiferum intrudentibus, hyphas intus evolventibus quae carnem exhaustiunt. Hyphae fertiles septatae, erectae, $250\text{--}450\ \mu$ altae, basi $4\text{--}8\ \mu$ crassae, sursum paulo fastigatae, prope apicem $2.2\text{--}3.3\ \mu$ crassae, ibi saepe plus minusve ramosae et ex sterigmatibus obtusis vulgo $2\text{--}10\ \mu$ longis, $2\text{--}3\ \mu$ crassis $3\text{--}15$ raro usque 25 conidia in capitulum laxum pulchrum aggregata gerentes. Conidia hyalina, speciose turbinata, $27\text{--}49\ \mu$ (saepe circa $37\ \mu$) longa, $15\text{--}23\ \mu$ (saepe circa $19.2\ \mu$) lata, $1\text{--}4$ septata, saepissime in 4 cellulis consistentia—cellula infima obconica saepe circa $5.8\ \mu$ longa, cellula antepaenultima disciformi saepe circa $4.9\ \mu$ longa, cellula paenultima ventricosa dolioformi saepe circa $22.7\ \mu$ longa, cellula summa apice rotundata saepe circa $4.6\ \mu$ longa. Chlamydosporae flavidae, globosae, plerumque $18\text{--}28\ \mu$ latae, maturitate membrana vulgo $1.4\text{--}2.5\ \mu$ crassa.

Vermiculos nematodeos multarum specierum vulgo usque $.6$ mm. longos irretiens consumensque habitat in radicibus *Spinaciae oleraceae* putrescentibus prope Norfolk, Virginia, etiam in humo silvestri prope Beltsville, Maryland; Madison, Wisconsin; et in Arlington, Virginia.

Mycelium spreading; the vegetative hyphae hyaline, septate, 2 to $8\ \mu$ wide, often, especially in the presence of nematodes producing bail-like arches and loops mostly 25 to $35\ \mu$ wide, which may remain discrete but are frequently compounded into networks,—the hyphal bails, loops, and networks capturing nematodes through adhesion and entanglement, then perforating the integument of

each animal and intruding a mortiferous excrescence that gives rise to assimilative hyphae which grow lengthwise through the body and appropriate the fleshy materials. Conidiophores hyaline, erect, septate, 250 to 450 μ high, 4 to 8 μ wide at the base, tapering upward to a width of 2.2 to 3.3 μ , simple or often somewhat branched near the tip, and there bearing on blunt sterigmata, mostly 2 to 10 μ long and 2 to 3 μ wide, usually 3 to 15, rarely up to 25 conidia in beautiful loose capitate arrangement. Conidia hyaline, handsomely top-shaped, rounded at the apex, tapering toward the frequently somewhat protruding truncate base, 27 to 49 μ (average 37 μ) long, 15 to 23 μ (average 19.2 μ) wide, containing 1 to 4 septa, but most often divided by 3 cross-walls into 4 cells—the obconical basal cell then averaging 5.8 μ in length, the disciform antepenultimate cell 4.9 μ , the broadly ventricose or barrel-shaped penultimate cell 22.7 μ , and the apical cell 4.6 μ . Chlamydospores yellow, globose or ellipsoidal, mostly 18 to 28 μ in diameter, at maturity surrounded by a wall commonly 1.4 to 2.5 μ thick.

Capturing and consuming nematodes generally up to .6 mm. long, referable to many species of *Acrobeles*, *Acrobeloides*, *Cephalobus*, *Diplogaster*, *Diploscapter*, *Plectus* and *Rhabditis*, it occurs in decaying roots of *Spinacea oleracea* near Norfolk, Va., and also in leaf mold in deciduous woods near Beltsville, Md., near Madison, Wis., and in Arlington, Va.

DACTYLARIA CANDIDA (Nees) Sacc.

The predacious fungus that was sketchily characterized in a synoptic account (12: p. 139, lines 20–24, fig. 6, A, B) as producing narrow spindle-shaped conidia in loose capitate arrangement, and that later (15) on somewhat more detailed consideration was identified with *Dactylaria candida*, has been observed from time to time in nematode-infested agar plate cultures to which small quantities of leaf mold had previously been added. Its effuse mycelium is somewhat delicate in comparison with the mycelium in most other nematode-capturing members of the series, the rather straightforward hyphae composing it measuring generally between 1.2 μ and 3 μ in width. On these hyphae, under conditions inviting its development, and more especially in the presence of free-living nematodes, is formed predacious apparatus consisting as in *Dactylella lysipaga* and *D. leptospora* of unicellular knobs and non-

constricting rings. The knobs, globose or prolate ellipsoidal in shape, measuring commonly 4 to 7μ in length and 3.8 to 6μ in width, are supported on slender stalks mostly 4 to 15μ long and 1 to 1.4μ wide (FIG. 15, *A*, *a-c*). The rings, usually 15 to 23μ in outside diameter, are composed generally of three arcuate cells 2.5 to 4μ in width; the proximal segment often being noticeably inflated where it joins the stalk, which is frequently circinate or otherwise curved, and measures commonly 10 to 35μ in length and 1.2 to 1.8 in width (FIG. 15, *B-J*).

The stalked knobs have rarely been seen operative, and then only in the capture of the smallest and feeblest nematodes; though as was intimated earlier their usual ineffectiveness in agar media need not imply any lack of competence in natural substrata of much different physical texture. Ensnarement in a ring, on the other hand, always results in destruction of the nematode concerned, regardless of whether the encircling structure remains attached to its stalk (FIG. 15, *K*), or is torn off therefrom (FIG. 15, *L*). The bursiform body, often about 8μ long and 6μ wide, that is intruded after the integument has been penetrated by a narrow process from the inner surface of the ring, is not sufficient to disable the animal, which therefore continues to move about with gradually diminishing briskness until assimilative hyphae have been extended well through its interior. In fairly large nematodes these hyphae, sometimes as much as 4μ wide, attain rather luxuriant development (FIG. 15, *L*). Appropriation of the fleshy contents makes possible the growth of new mycelial filaments arising mainly from the outer surface of the ring.

Thus both in structure and in operation of its predacious organs the fungus shows an obvious parallelism to *Dactylella lysipaga* that is extended, though with a smaller degree of exactness, in its conidial apparatus. Sporulation, especially in pure culture, is inclined to be capricious, sometimes taking place only on a very meager scale despite a vigorous condition of the underlying mycelium. Exposure to sunlight for brief periods has often proved helpful in stimulating reproductive development in refractory material; yet even under the most favorable conditions the conidiphores scarcely ever become clearly visible to the naked eye. Commonly 3 to 5μ in diameter at the base, they taper gradually upward

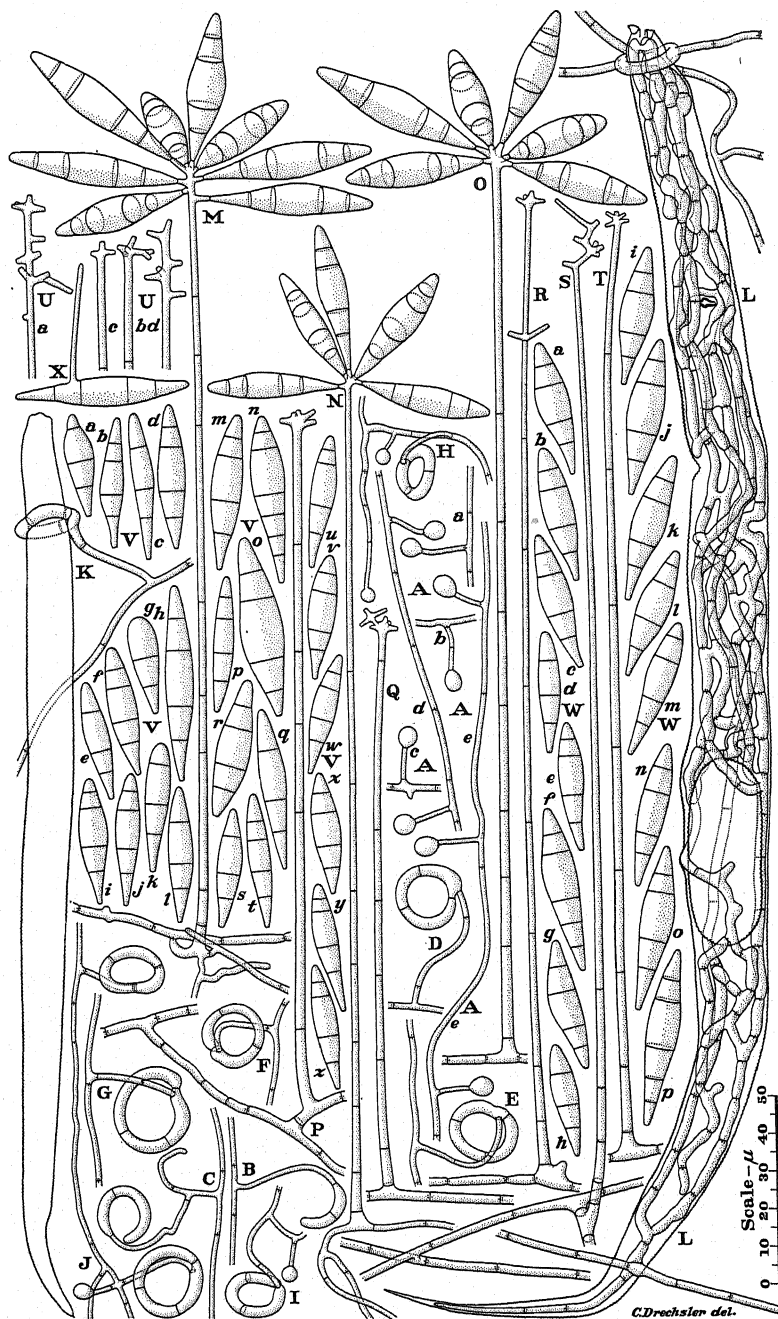


FIG. 15. *Dactylaria candida*.

to a width of 1.3 to 2.4 μ near the tip, where, 150 to 300 μ or even 400 μ above the substratum, 3 to 10 conidia are borne in strikingly handsome capitate arrangement (FIG. 15, *M*, *N*, *O*). As was set forth earlier, the spores are attached individually to stubby sterigmata, usually simple yet occasionally branched, and measuring commonly 2 to 12 μ in length, 1 to 2 μ in width at the base, and .8 to 1.4 μ in width at the apex (FIG. 15, *P-T*; *U*, *a-d*). The conidia themselves vary in shape from clavate-fusoid to fusoid; in length from 26 μ to 52 μ , mostly from 30 μ to 45 μ ; and in diameter from 5.5 μ to 11.5 μ , mostly from 7 μ to 10 μ (FIG. 15, *V*, *a-z*; *W*, *a-p*). While the number of cross-walls dividing the conidia varies from two in some of the shorter specimens, to six in some of the longer ones, the 4-septate condition, with the partitions so spaced as to give greater length to the median or antepenultimate cell than to any of the other segments, generally predominates. On rather dry substrata fallen conidia often show repetitive development in giving rise to small conidiophores (FIG. 15, *X*) and secondary conidia.

From *Dactylella lysipaga* the fungus under discussion differs mainly in the lesser diameter of its conidia, and in the production of these bodies in heads rather than singly or, at most, in pairs. The capitate habit here can not be considered as resulting from luxuriant development any more than the usually solitary sporulating habit of *D. lysipaga* or of *D. ellipsospora* can be regarded as expressive of a depauperate condition. For however abundantly spores may be formed in cultures of the latter two species, a capitate arrangement is never brought about; whereas in cultures of the present form the conidia are disposed in heads even when produced only in meager quantity.

The fungus is identified as *Dactylaria candida* mainly because of its general agreement with the diagnosis given by Saccardo (61) for that species. Historically the species dates back to 1816 when the elder Nees von Esenbeck (50) described under the binomial *Dactylium candidum* a white, gregarious, inconspicuously pulverulent mold found on the inner surface of old loosened oak bark—erecting on it a genus characterized by simple upright hyphae bearing terminally three or four elongate-clavate, short-celled conidia. No statement was made regarding the number of cross-walls in the conidia, but the minute figure accompanying the de-

scription shows a decided predominance of 3-septate over 4-septate spores. Conidia with three cross-walls preponderate seemingly to the exclusion of 4-septate specimens in the equally minute figures of the species published by Chevallier (7) a decade later. In 1837 the younger Nees von Esenbeck and Henry (51) published illustrations of *D. candidum* showing some 3-septate conidia together with a smaller number of 4-septate ones. Later Bonorden (5) in a figure of *D. candidum*, drawn presumably at first hand and to a slightly less parsimonious scale, represented conidia containing four cross-walls in equal number with conidia having five cross-walls. Oudemans (52), who recognized as *D. candidum* a form growing on goat dung and producing spores 46 to 56 μ long and 7 to 9.3 μ wide, disapproved of Bonorden's illustration on the ground that it exaggerated the number of conidial septa, which he considered more accurately set forth in Nees' figure. Nevertheless, when soon thereafter Saccardo transferred the species to the newly erected genus *Dactylaria*, his diagnosis brought together Bonorden's representations concerning spore septation with the metric data supplied by Oudemans. The description thus compiled was adopted by Lindau without significant change.

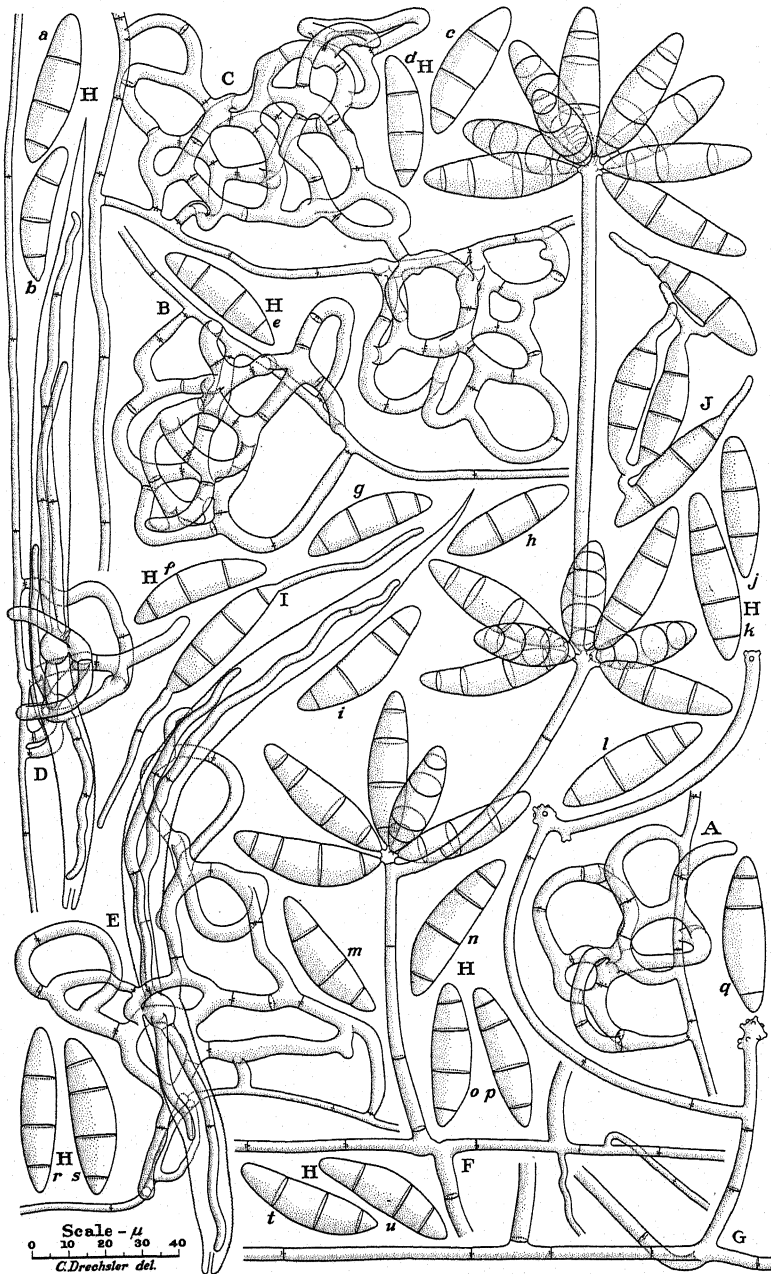
References to *Dactylaria candida* in the more recent as also in the older literature are so few that an established usage relative to the binomial can hardly be said to exist. The substrata on which the species has been reported, decaying oak bark and goat dung are materials congenial for the development of nematodes, and consequently also for the development of fungi that subsist on these animals. The reproductive habit described and figured in the older accounts conforms at least in a general way with that of predacious fungi when found on natural substrata. Finally, whether by accident or because of specific identity, the morphological details set forth in the diagnosis generally accepted for the species agree so well with those revealed in the predacious fungus under consideration, that for the present at least, disposition of the latter elsewhere could not readily be defended.

DACTYLARIA POLYCEPHALA

A fungus of more than ordinary taxonomic interest made its appearance a few times in nematode-infested agar plate cultures to

which had been added small quantities of decaying leaves and stems of the baby-dewflower (*Commelina longicaulis* Jacq.) kindly supplied by F. L. Wellman from his plots in an experimental greenhouse. Here and there on the rather delicate straightforward hyphae that made up its sparse mycelium were borne predacious networks resembling in general design those of *Dactylaria thaumasia* and the retiare species of *Arthrobotrys*. A distinctive difference was nevertheless evident in that the networks here, though frequently more extensive than in other forms, were composed of noticeably smaller hyphal bails (FIG. 16, A-C) and thus presented a characteristically more intricate appearance. Moreover, the reticula were developed under the surface of the substratum much more generally than are the predacious networks of other retiare species. In operation, on the other hand, they revealed no new departure. Capture of nematodes was effected through adhesion and entanglement; the integument of each animal was narrowly perforated; a bulbous structure was intruded into the captive; and from the bulbous structure assimilative hyphae were extended lengthwise through the paralyzed body to appropriate the degenerating fleshy materials (FIG. 16, D, E).

In nematode-infested cultures the erect conidiophores were often widely scattered, and usually grew to a height of 100 to 250 μ before giving rise to the single terminal cluster of conidia. Far more luxuriant development ensues when the fungus is grown in pure culture on maize meal agar. A beautiful pinkish aerial mat is then produced, which under the microscope is seen to be composed of numerous sporophores, often somewhat prostrate and entangled with one another. An individual sporophore here, after producing a first conidial cluster sometimes no more than 50 μ from its base, gives rise successively to additional clusters following repeated elongation from the sporiferous tip, varied occasionally by lateral branching some distance below the tip (FIG. 16, F, G). The conidia slightly resemble those of *Arthrobotrys musiformis* in general shape, but differ from them in being larger and more abundantly septate (FIG. 16, H, a-u). Of the 100 conidia taken at random whose measurements were used to obtain the relevant metrical data submitted in the diagnosis below, 59 were divided by four cross-walls, 36 were divided by three cross-walls, and 5,

FIG. 16. *Dactylaria polycephala*.

probably somewhat immature, were divided by two cross-walls. Germination takes place by the production usually of two polar germ tubes (FIG. 16, I). In moist material anastomoses of germ tubes with one another or with conidia (FIG. 16, J), and, indeed, vegetative fusion of mycelial filaments generally, occur frequently as in other members of the series.

The fungus shows such obvious parallelism, both in reproductive habit and in make-up of predacious apparatus, to the retiary species of *Arthrobotrys* that its assignment to another genus, however clearly necessitated by the plural septation of its conidia, can not be regarded with any gratification. Unfortunately, besides, in the definition of *Dactylaria*, to which among existing phragmosporous genera it needs to be referred, no provision is made for nodose or repeatedly capitate forms. A rather slight modification in generic concept to allow the inclusion here of such a repeatedly capitate form, like the opposite extension of *Arthrobotrys* to permit inclusion of the monocephalous species *A. musiformis* and *A. dactyloides*, appears somewhat preferable to the erection of a new genus.

Dactylaria polycephala sp. nov.

Mycelium effusum; hyphis hyalinis, septatis, $1.8-4.5\ \mu$ crassis, laqueos tenaces arcuatos vel circulares, $15-25\ \mu$ latos in retia pulchra magna saepe conjunctos evolventibus—his laqueis retibusque vermiculos nematodeos illaqueantibus, diende tum integumentum perforantibus, tuber debilitans intrudentibus, hyphas intus evolventibus quae carnem exhauriunt. Hyphae fertiles hyalinae, septatae, primo erectae, postea saepe plus minusve procumbentes, $3-4.5\ \mu$ crassae, $50-250\ \mu$ supra basin 3-12 subinde usque 15 conidia in capitulum primum ferentes, deinde identidem recrescentes alia similia capitula deinceps gerentes. Conidia hyalina, fusoideo-ellipsoidea, apice rotundata, basi acutiuscula, subinde 2-septata, saepe 3-septata, saepissime 4-septata, ad septa interdum leviter constricta, $35-46\ \mu$ (saepe circa $40.7\ \mu$) longa, $8.5-12.5\ \mu$ (saepe circa $10.9\ \mu$) lata.

Vermiculos nematodeos multarum specierum vulgo usque .5 mm. longos laqueans consumensque habitat in foliis caulibusque *Commelinae longicaulis* putrecentibus in viridario prope Beltsville, Maryland.

Mycelium spreading; the vegetative hyphae hyaline, septate, mostly 1.8 to $4.5\ \mu$ wide, often especially in the presence of nematodes, producing from anastomosing elements 3 to $6\ \mu$ wide, hyphal bails and loops 15 to $25\ \mu$ in diameter, which, at first discrete, are later usually compounded into handsome, extensive networks—these bails, loops, and networks capturing nematodes through ad-

hesion and entanglement, then perforating the integument of each animal, and intruding a disabling globose excrescence that gives rise to assimilative hyphae which grow lengthwise through the body and appropriate the fleshy materials. Conidiophores hyaline, septate, at first erect, later often more or less procumbent, 3 to $4.5\ \mu$ wide, at a distance of 50 to $250\ \mu$ from the base producing 3 to 12 conidia, occasionally up to 15 conidia, in a terminal head, then following repeated elongation often giving rise successively to additional conidial clusters. Conidia hyaline, fusoid-ellipsoidal, rounded at the distal end, somewhat acute at the base, occasionally 2-septate, often 3-septate, most often 4-septate, sometimes slightly constricted at the septa, 35 to $46\ \mu$ (average $40.7\ \mu$) long, 8.5 to $12.5\ \mu$ (average $10.9\ \mu$) wide.

Capturing and consuming nematodes commonly up to .5 mm. in length, belonging to many species of *Plectus* and *Rhabditis*, it occurs in decaying leaves and stems of *Commelina longicaulis* in a greenhouse near Beltsville, Md.

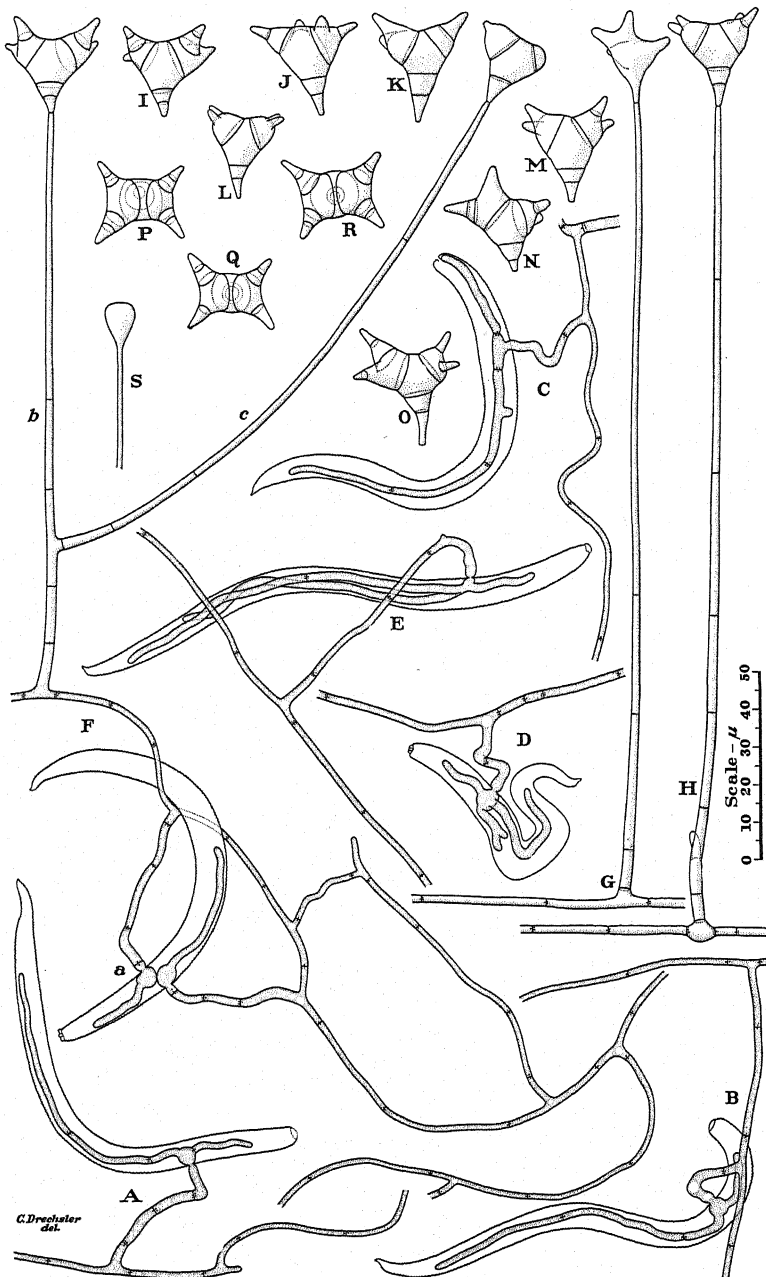
TRIPOSPORINA APHANOPAGA

The weakly predacious fungus with inversely pyramidal conidia that was briefly discussed and illustrated in an earlier summary (12: p. 139, fig. 9, A, C; p. 140, lines 14–22) has been observed occasionally in nematode-infested agar plate cultures following the addition of small quantities of leaf mold. In such cultures it apparently always subsists on nematodes, though well differentiated organs of capture have never been seen associated with the narrow filaments that make up its sparse mycelium. Only very small eelworms have been found utilized, their contents in each instance being appropriated by means of assimilative hyphae extending lengthwise through the fleshy interior. These assimilative hyphae arise from a usually somewhat swollen cell manifestly intruded, after narrow perforation of the integument, from the tip of a hyphal branch variable in length and generally slightly wider than the parent mycelial filament (FIG. 17, A-E; F, a). An arrangement of parts is thus evident corresponding essentially to that revealed when nematodes have been captured and are being exhausted of their digestible substance by *Dactylella ellipsospora* or *D. asthenopaga*. The thoroughgoing analogy strongly suggests that the present species before consuming a nematode first cap-

tures it through adhesion; though active struggles testifying to a predacious relationship have so far not come under observation.

As might be expected in view of its feeble aggressiveness, the fungus gives rise only to meager reproductive apparatus. In stature, in an occasional branching habit, and in frequent production of secondary conidiophores, its fertile hyphae (FIG. 17, *F, b; G, H*) invite comparison with those of the less robust species of *Dactylella*, and more particularly, perhaps, with the sporophores of *D. asthenopaga*. Much more distinctiveness attaches to the conidia; first appearing as obconical or inverted flask-shaped terminations (FIG. 17, *S*), they bifurcate twice at broad angles (FIG. 17, *G*) to develop into obpyramidal bodies with usually four divergent distal apices (FIG. 17, *F, b; H-R*). The number of partitions in the conidia varies from three in obviously imperfect specimens (FIG. 17, *F, c*), to twelve in specimens that may be considered perfect with regard to cellular composition (FIG. 17, *P, R*). The 13 segments making up the 12-septate conidia include a small, often obconical basal segment; a widening disciform segment adjacent to the basal one; a large central segment, distally wedge-shaped, third in position from the base, and forming the terminal portion of the axis; two largish paired antepenultimate segments, hemicylindrical in shape, borne on the oblique converging facets of the central segment, their long axes directed parallel to one another and at right angles to the main axis; four small tapering disciform penultimate segments, one being joined to each end of the two antepenultimate segments; and finally four small conical distal segments, each surmounting one of the penultimate segments, and forming with it one of the four divergent terminations. Reduction in number of cross-walls usually comes about through omission of one or both partitions in one or more of the distal terminations (FIG. 17, *F, b; H, I-O; Q*), less often through omission of a septum in the axial part (FIG. 17, *F, c*).

In pure culture on maize meal agar the fungus extends its mycelium radially only about .1 mm. in 24 hours—less than any other member of the predacious series, not even excepting such slow-growing forms as *Dactylella bembicodes* and *Pedilospora dactylo-paga*. Slow vegetative growth would seem rather frequently associated in the series with a branched condition of the conidia—

FIG. 17. *Triposporina aphanopaga*.

the association, if somewhat unusual among nematode-capturing members, coming to light often among forms predacious on rhizopods or parasitic on other fungi. As was intimated earlier (16), the distinctive conidium of the species under consideration may be construed as a conidium of the broad type found in *D. bembicodes* that has been modified by two successive bifurcations. It appears to conform in general design to requirements set forth by Höhnelt (33) in his diagnosis of the genus *Triposporina*. Since *T. uredinicola* Höhn., on which the genus was erected, is parasitic on the rust *Puccinia Derris* (P. H.) Höhn., it may possibly belong in the predacious series; though specific identity with my fungus would seem definitely precluded by the proportionately much smaller central cell and the generally different conidial shape depicted in Höhnelt's figures.

An epithet compounded of two words meaning "unseen" and "trap" respectively, may appropriately suggest the absence of conspicuously differentiated predacious organs.

Triposporina aphanopaga sp. nov.

Mycelium parvum; hyphis sterilibus hyalinis, septatis, vulgo 1.5–3 μ crassis, ramos saepe 20–75 μ longos, 2–3.5 μ crassos gerentibus,—his ramis vermiculos nematodeos attingentibus, integumentum eorum perforantibus, tuber circa 5 μ lata interdum intrudentibus, hyphas intus semper evolventibus quae carnem exhauriunt. Hyphae fertiles hyalinae, erectae, septatae, simplices vel parce ramosae, 150–275 μ altae, basi circa 3 μ crassae, sursum leviter fastigatae, apice circa 1.5 μ crassae, unicum conidium saepius ferentes. Conidia hyalina, 20–25 μ longa, bis late bifurca itaque obpyramidalia, 3–12 septata; quandocunque in 13 loculos divisa parte infima obconica ex 2 loculis parvis composita, parte media in cellula magna sursum aliquantum cuneata consistente, parte summa in binis cellulis oblique lateralibus antepaenultimis ambabus in corniculum conicum biloculare utrumque abeuntibus consistente—4 bilocularibus corniculis divaricatis, binis unius antepaenultimae cellulae inter se apice 16–22 μ distantibus, binis ex aliis cellulis antepaenultimis inter se apice 20–25 μ distantibus.

Vermiculos nematodeos minutos, praesertim pullulos *Plecti communis* et *Plecti parvi* consumens, habitat in humo silvestri, prope Beltsville, Maryland, et in Arlington, Virginia.

Mycelium meager; vegetative hyphae hyaline, septate, commonly 1.5 to 3 μ wide, here and there bearing branches often 20 to 75 μ long and 2 to 3.5 μ wide—these branches individually becoming applied to nematodes, narrowly perforating the integument of each animal, sometimes intruding a globose body about 5 μ in diameter, but in any case extending lengthwise through the interior assimi-

lative hyphae that appropriate the fleshy contents. Conidiophores hyaline, septate, erect, simple or occasionally branched, 150 to 275 μ high, about 3 μ wide at the base, tapering gradually upward to a width of approximately 1.5 μ at the apex, and there bearing a single conidium. Conidia hyaline, 20 to 25 μ in length along the vertical axis, successively twice dichotomous at wide angles, inversely pyramidal, containing 3 to 12 septa,—in specimens divided by 12 septa into 13 cells, the lower part obconical and composed of 2 small cells; the middle part consisting of a large cell, obconical below, inversely wedge-shaped above; the upper part composed of 2 largish paired cells, hemicylindrical in shape, their long axes parallel to one another but at right angles to the main axis, each terminating at both of its ends in a 2-celled conical process—the apices of two processes from the same antepenultimate cell 16 to 22 μ apart, those of two processes on the same side of the spore but borne on separate antepenultimate cells generally 20 to 25 μ apart.

Subsisting on small nematodes, more particularly on larvae of *Plectus communis* Bütschlii and *P. parvus* Bastian, it occurs in leaf mold in deciduous woods near Beltsville, Md., and in Arlington, Va.

TRICHOHECIUM POLYBROCHUM

The fungus producing large, obovoid, uniseptate conidia and constricting rings that was dealt with synoptically in an earlier summary (12: p. 139, fig. 10, A-C; p. 140, lines 22–30) has not been seen elsewhere than in the nematode-infested agar plate culture in which it was first encountered. As at the time there was no reason for expecting any difficulty in recovering the species, the material was given little more than the usual preliminary study; so that of necessity the present treatment remains somewhat deficient in detail. Fortunately the predacious organs need no extended description, consisting as they do of constricting rings closely similar to those of *Arthrobotrys dactyloides*, *Dactylella bembicodes* and *Dactylaria brochopaga* not only in arrangement (FIG. 18, A, a-c) and structure (FIG. 18, B) but also in manner of operation (FIG. 18, C). The conidiophores are sturdy and tall like the fertile hyphae of *Dactylella bembicodes*, and like these, too, bear a single large obovoid conidium (FIG. 18, D). Division of the conidium into a small basal cell and a very much larger distal

cell, and the envelopment of the distal cell in a hyaline mucous coating, provide the most distinctive characteristics of the species (FIG. 18, *E*, *a*, *b*). Though germination readily takes place when conidia are placed in water, generally being initiated by the production of a germ tube from the small basal cell (FIG. 18, *E*, *c*), efforts at isolating the fungus were defeated by early multiplication of bacteria commonly adhering to the gelatinous envelope.

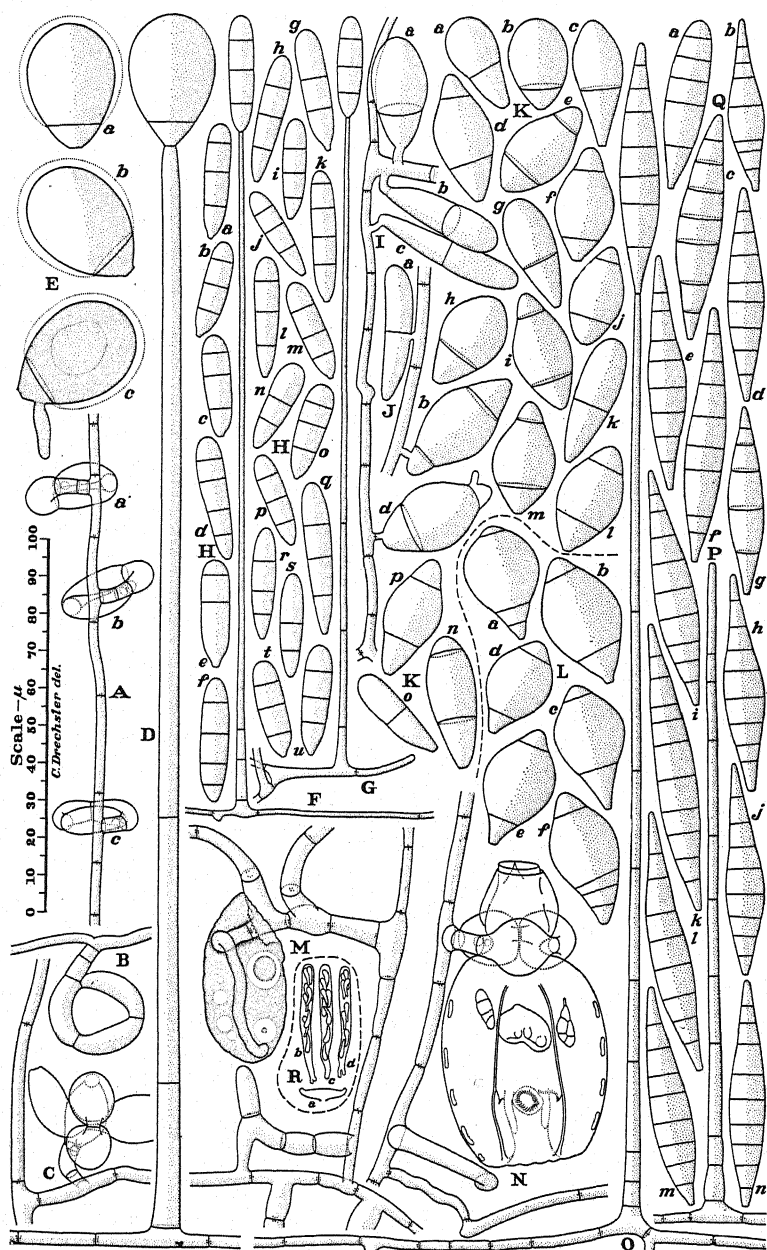
Because of the morphology of its conidial apparatus the species must be referred to *Trichothecium* despite the absence of any close kinship to *T. roseum*, the accepted and widely familiar type of that genus. Judging from the figures of Massee and Salmon (46), there would seem to be some likelihood, however, that it may be a relative of *T. inaequale*, whose occurrence on dung suggests the possibility of a predacious habit. From *T. inaequale*, as, indeed, from all other forms collected in the genus, the present fungus differs in its more robust stature and greater dimensions throughout. It is accordingly described as a new species, under a name meaning "with many nooses."

Trichothecium polybrochum sp. nov.

Mycelium effusum; hyphis hyalinis, septatis, 2-4.5 μ crassis, laqueos circulares 22-30 μ latos in 3 cellulis arcuatis consistentis ex ramulo biloculari circa 10 μ longo, 4 μ crasso proferentibus; his laqueis vermiculos nematodeos illaqueantibus, deinde tum per contractionem inflationemque trium cellularum animalia magnopere comprimentibus, ita haec interficientibus, statim integumentum perforantibus et hyphas intus evolventibus quae carnem exhauriunt. Hyphae fertiles hyalinae, septatae, erectae, saepe 275-400 μ altae, basi circa 7 μ crassae, sursum leviter fastigatae, apice circa 3 μ crassae, unicum conidium ferentes. Conidia hyalina, late obovoidea, plerumque circa 35 μ longa, 24 μ crassa, uniseptata, loculo inferiore obconico circa 6.5 μ longo, loculo superiore multo majore, mucro fere tecto, circa 28.5 μ longo.

Vermiculos nematodeos diversos vulgo usque .5 mm. longos capiens consumensque habitat in radicibus putrescentibus *Spinaciae oleraceae* prope Norfolk, Virginia.

Mycelium spreading; vegetative hyphae hyaline, septate, 2 to 4.5 μ wide, in the presence of nematodes producing underneath and at right angles to their axes approximately circular rings 22 to 30 μ in outside diameter, composed individually of 3 arcuate cells, the first and third of which are united to one another and to the distal end of a frequently somewhat curved supporting branch about 10 μ long, 4 μ wide and composed usually of 2 cells whereof the proximal one is usually the shorter; following ensnarement of a

FIG. 18. *Trichothecium polybrochum*.

nematode, the individual ring, through contraction and inflation of its component arcuate cells constricting the animal to death, or into a state of reduced activity preceding death, then perforating the integument and giving rise to assimilative hyphae that extend lengthwise through the interior and appropriate the fleshy materials. Conidiophores hyaline, septate, erect, 275 to 400 μ high, about 7 μ wide at the base, tapering gradually upward to a diameter of about 3 μ at the tip, there bearing a single conidium. Conidia hyaline, broadly obovoid, mostly about 35 μ long, 24 μ wide, divided by a single septum into a small obconical basal cell about 6.5 μ long, and a much larger distal cell, about 28.5 μ long, which after falling off, if not before, is often enveloped in a hyaline layer of mucus 2 to 3 μ thick.

Capturing and consuming nematodes usually up to .5 mm. in length, belonging to various species of *Cephalobus*, *Plectus* and *Rhabditis*, it occurs in decaying rootlets of *Spinacia oleracea* near Norfolk, Va.

DACTYLELLA TENUIS

In old nematode-infested agar plate cultures, following the addition of leaf mold, a fungus occasionally develops, which, though presenting much the same general appearance as various members of the predacious series, has never been detected in a predacious relationship. Now and then branches from its delicate mycelium have been found parasitizing oöspores of *Pythium Butleri* or of *P. ultimum* Trow; but the parasitism seemed generally to be of an adventitious sort, and occurred mostly on a scale insufficient to account in any large measure for the growth of the mycelium present, scanty though this frequently was. The fungus, whether essentially of biogenous character or not, is presented here partly in order to forestall confusion with *Dactylella asthenopaga*, which it resembles rather closely in the stature of its fertile hyphae (FIG. 18, F, G) as well as in the dimensions and septation of its conidia (FIG. 18, H, a-u). However, their usually rounded cylindrical shape distinguishes these conidia as conclusively from the obconical spores of *D. asthenopaga* as their division into segments of approximately equal lengths distinguishes them from the unequally segmented conidia of *Dactylaria brochopaga*. In pure culture the fungus grows readily, producing a mycelium composed of hyphae appreciably narrower than those of any of the related forms known

to prey on nematodes. An epithet having reference to this delicate vegetative habit is deemed appropriate for the species, which appears separate on the same grounds as *D. asthenopaga* from the various fungi described as members of the genus *Dactylella* and of the apparently synonymous *Monacrosporium*.

***Dactylella tenuis* sp. nov.**

Mycelium effusum; hyphis sterilibus hyalinis, ramosis, septatis, 1-2 μ crassis; hyphis fertilibus hyalinis, erectis, septatis, 100-200 μ altis, basi 2.5-4 μ crassis, sursum fastigatis, apice 1-1.5 μ crassis, unicum conidium ferentibus; conidiis cylindricis, apice rotundatis, basin versus plus minusve attenuatis, 25-41 μ (saepe circa 30 μ) longis, 6.3-8.2 μ (saepe circa 7 μ) crassis, 1-4-septatis, vulgo tribus septis in 4 loculos subaequales divis.

Oosporas *Pythii Butleri* et *Pythii ultimi* rarerer consumens habitat in humo silvestri prope Beltsville, Maryland et in Arlington, Virginia.

Mycelium spreading; the vegetative hyphae hyaline, branching, septate, 1 to 2 μ wide; conidiophores hyaline, erect, septate, 100 to 200 μ high, 2.5 to 4 μ wide at the base, tapering upward to a width of 1 to 1.5 μ , bearing terminally a solitary conidium; conidia hyaline, cylindrical, rounded at the distal end, tapering somewhat toward the slightly protruded truncate base, 25 to 41 μ (average 30 μ) long, 6.3 to 8.2 μ (average 7 μ) wide, containing 1 to 4 cross-walls but most frequently divided by 3 cross-walls into 4 segments not regularly or conspicuously differing in length.

Occasionally parasitic on oöspores of *Pythium Butleri* and *P. ultimum*, it occurs in leaf mold in deciduous woods near Beltsville, Md., and in Arlington, Va.

DACTYLELLA RHOMBOSPORA GROVE

From the same decaying leaves and stems of *Commelina longicaulis* that yielded cultures of *Dactylaria polycephala* was obtained also a fungus which like *Dactylella tenuis* must almost certainly be a member of the predacious series, yet has so far not revealed any predacious activity when planted in agar cultures well infested with nematodes as well as with various testaceous rhizopods and different species of *Amoeba*. Its effuse mycelium, nearly invisible in pure culture on maize meal agar, consists of rather straightforward septate branching hyphae, mostly 2 to 3.5 μ wide, from which arise, usually somewhat sparsely, erect conidiophores (FIG. 18, O, P) 125 to 250 μ high, 4 to 6 μ wide at the base, tapering

gradually upward to a width of 1.5 to 2 μ at the tip, on which is borne a single conidium. The conidia, sometimes clavate-fusoid (FIG. 18, Q, a), but much more frequently and more typically spindle-shaped with elongate symmetrically rhomboid profile (FIG. 18, Q, b-n), measure 46 to 71 μ (average 60.3 μ) in length and 9.5 to 11.8 μ (average 10.6 μ) in width. They contain from 5 to 10 (average 7.7) septa, 8 cross-walls being present usually in a decided majority of spores in any random assortment. Though Grove's (27) figures indicate perhaps a slightly greater conidial diameter, the fungus agrees well enough in general morphology with *Dactylella rhombospora* to justify referring it to that species at least provisionally.

DIVISION OF FRUIT AND VEGETABLE CROPS AND DISEASES,
BUREAU OF PLANT INDUSTRY,
U. S. HORTICULTURAL FIELD STATION,
BELTSVILLE, MD.

LITERATURE CITED

1. Bail, T. Mykologische Berichte. Bot. Ztg. 13: 673-682. 1855.
2. Bary, A. de. Bemerkungen zu vorstehendem Aufsatz. Bot. Ztg. 25: 75-77. 1867.
3. Berlese, N. A. Fungi veneti novi vel critici. Malpighia 1: 531-536. 1887; 2: 99-106, 241-250. 1888.
4. Boedijn, K. B. Beitrag zur Kenntnis der Pilzflora von Sumatra. Rec. Trav. Bot. Néer. 26: 396-439. 1929.
5. Bonorden, H. F. Handbuch der allgemeinen Mykologie. 1851.
6. Bukák, F. Neue oder kritische Pilze. Ann. Myc. 4: 105-124. 1906.
7. Chevallier, F. F. Flore générale des environs de Paris, selon la méthode naturelle 1. 1826.
8. Coemans, E. Révision des genres *Gonatobotrys* et *Arthrobotrys* Corda. Bull. Soc. Roy. Bot. Belgique 2: 167-178. 1863.
9. Constantin, J. Les mucédinées simples. 1888.
10. Corda, A. C. J. Pracht-Flora europaeischer Schimmelbildungen. 1839.
11. Dangeard, P. A. Sur le nouveau genre *Protascus*. Le Botaniste 9: 23-25. 1903.
12. Drechsler, C. Morphological diversity among fungi capturing and destroying nematodes. Jour. Wash. Acad. Sci. 23: 138-141. 1933.
13. —. Morphological features of some more fungi that capture and kill nematodes. Jour. Wash. Acad. Sci. 23: 267-270. 1933.
14. —. Several more fungi that prey on nematodes. Jour. Wash. Acad. Sci. 23: 355-357. 1933.

15. —. Organs of capture in some fungi preying on nematodes. *Mycologia* 26: 135–144. 1934.
16. —. *Pedilospora dactylophaga* n. sp., a fungus capturing and consuming testaceous rhizopods. *Jour. Wash. Acad. Sci.* 24: 395–402. 1934.
17. —. A new species of conidial Phycomycete preying on nematodes. *Mycologia* 27: 206–215. 1935.
18. —. A new Mucedinaceous fungus capturing and consuming *Amoeba verrucosa*. *Mycologia* 27: 216–223. 1935.
19. —. A new species of *Stylopage* preying on nematodes. *Mycologia* 28: 241–246. 1936.
20. —. A *Fusarium*-like species of *Dactylella* capturing and consuming testaceous rhizopods. *Jour. Wash. Acad. Sci.* 26: 397–404. 1936.
21. Eisenach, H. Uebersicht der bisher in der Umgegend von Cassel beobachteten Pilze. 36 p. Cassel, 1878.
22. Elliott, J. S. B. On the method of growth of the conidial clusters of *Trichothecium roseum*. *Trans. Brit. Myc. Soc.* 6: 37–38. 1918.
23. Fresenius, G. Beiträge zur Mykologie. Heft 1–2: 1–80. *pl.* 1–9. 1852.
24. Gicklhorn, J. Studien an *Zoophagus insidians* Som., einem Tiere fangenden Pilz. *Glasnik Soc. Sci. Nat. Croate* 34: 198–229. 1922.
25. Girzitska, Z. On the effect of different manures on the mycoflora of the soil. *Jour. Inst. Bot. Acad. Sci. Ukraine* 8 (16): 43–54. 1936.
26. Goffart, H. Untersuchungen am Hafernematoden *Heterodera schachtii* Schm. unter besonderer Berücksichtigung der schleswig-holsteinischen Verhältnisse I. III. Beitrag zu: Rassenstudien an *Heterodera schachtii* Schm. *Arb. Biol. Reichsanstalt Land- u. Forstw.* 20: 1–26. 1932.
27. Grove, W. B. New or noteworthy fungi: Part II. *Jour. Bot.* 23: 129–134; 161–169. 1885.
28. —. New or noteworthy fungi: Part III. *Jour. Bot.* 24: 129–137, 197–206. 1886.
29. —. New or noteworthy fungi: Part IV. *Jour. Bot.* 50: 9–18; 44–55. 1912.
30. Harz, C. O. Ueber *Trichothecium roseum* Link und dessen Formen. *Verhandl. K. K. Zool. Bot. Ges. Wien.* 21: 1369–1374. 1871.
31. —. Einige neue Hyphomyceten Berlin's and Wien's nebst Beiträgen zur Systematik derselben. *Bull. Soc. Imp. Nat. Moscou* 44 (I): 88–147. 1871.
32. Hoffmann, H. Spermatien bei einem Fadenpilze. *Bot. Ztg.* 12: 249–254, 265–269. 1854.
33. Höhnelt, F. von. Fragmente zur Mykologie (XIV. Mitteilung, Nr. 719 bis 792). *Sitzungsb. Kais. Akad. Wiss., Math. Naturw. Klasse, Abt. 1.* 121: 339–424. 1912.
34. Karsten, H. Einige Bemerkungen über die von Münter S. 250 angeregten Fragen und die von Bary (Bot. Zeitg. 1867 Nr. 10)

- gegebene Beantwortung derselben. Bot. Unters. Physiol. Laboratorium Landw. Lehranst. Berlin 1: 678-683. 1867.
35. Korab, I. I. [Results of a study of the beet nematode *Heterodera schachtii* Schm. according to investigations carried out at the nematode laboratory at Belozerkovsk. Ukrainian Research Institute for the sugar industry, Kiev] 8 (16): 29-67. 1929. [In Russian with English summary.]
 36. Kostka, G. Nematodenfangende Pilze. Mikrokosmos 21: 151-156. 1928.
 37. Lind, J. Danish fungi as represented in the herbarium of E. Rostrup. 1913.
 38. Lindau, G. Die Pilze Deutschlands, Oesterreichs und der Schweiz. VIII. Abteilung: Fungi imperfecti: Hyphomycetes (erst Hälfte). In Rabenhorst L. Kryptogamen-Flora. Ed. 2, 1^s: —. 1904-1907.
 39. Linder, D. H. North American Hyphomycetes. II. New species and a new genus. Mycologia 26: 436-440. 1934.
 40. Linford, M. B. Stimulated activity of natural enemies of nematodes. Science 85: 123-124. 1937.
 41. Loew, E. Ueber *Arthrobotrys oligospora* Münter. Bot. Ztg. 25: 73-75. 1867.
 42. —. Ueber zwei kritische Hyphomyceten (*Acrotalagmus* Corda und *Arthrobotrys oligospora* Fres.). Jahres-Bericht über die Königliche Realschule, Vorschule und Elisabethschule zu Berlin 1874: 3-15. 1874.
 43. Mahju, N. A. A contribution to our knowledge of Indian coprophilous fungi. Jour. Indian Bot. Soc. 12: 153-164. 1933.
 44. Marchal, É. Champignons coprophiles de Belgique. Bull. Soc. Roy. Bot. Belgique 34: 125-149. 1895.
 45. Massee, G. New British micro-fungi. Jour. Roy. Micros. Soc. II, 5: 757-760. 1885.
 46. — & E. S. Salmon. Researches on coprophilous fungi. II. Ann. Bot. 16: 57-93. 1902.
 47. Matruchot, L. Recherches sur le développement de quelques mucédinées. 1892.
 48. Mirande, R. *Zoöphagus insidians* Sommerstorff, capteur de rotifères vivants. Bull. Soc. Myc. France 36: 47-53. 1920.
 49. Münter, J. Ueber Fichtennadelrost. Bot. Unters. physiol. Laboratorium landw. Lehranst. Berlin 1: 221-256. 1866.
 50. Nees von Esenbeck, C. G. Das System der Pilze und Schwämme. 1816, 1817.
 51. Nees von Esenbeck, T. F. L. & A. Henry. Das System der Pilze. Abt. I. 1837.
 52. Oudemans, C. A. J. A. Aanwinsten voor de flora mycologica van Nederland, IX en X. Nederl. Kruidk. Arch. II. 4: 203-278. 1885.
 53. Petch, T. Additions to Ceylon fungi (II). Ann. Roy. Bot. Gardens Peradeniya 7: 279-322. 1922.
 54. Preuss, G. T. Uebersicht untersuchter Pilze, besonders aus der Umgegend von Hoyerswerda. Linnaea 24: 99-153. 1851.

55. —. Uebersicht untersuchter Pilze, besonders aus der Umgegend von Hoyerswerda. *Linnaea* 26: 705–725. 1853.
56. Rahm, P. G. Biologische und physiologische Beiträge zur Kenntniss der Moosfauna. *Zeits. Allgem. Phys.* 20: 1–34. 1922.
57. Rea, C. New or rare British fungi. *Trans. Brit. Myc. Soc.* 3: 285–289. 1911.
58. Reinhardt, M. O. Mykologische Mittheilungen. *Ber. Deut. Bot. Ges.* 45: 131–138. 1927.
59. Rostrup, O. Bidrag til Danmarks svampeflora. I. *Dansk Bot. Arkiv* 2 (5): 1–56. 1916.
60. —. Bidrag til Danmarks svampeflora. II. *Dansk Bot. Arkiv* 8 (8): 1–74. 1935.
61. Saccardo, P. A. *Sylloge fungorum* 4. 1886.
62. —. *Sylloge fungorum* 10: 552. 1892.
63. Schmidt, A. Die Verbreitung der coprophilen Pilze Schlesiens. Breslau, 1912.
64. Sherbakoff, C. D. A new fungus parasitic on nematodes. *Mycologia* 25: 258–262. 1933.
65. Smith, A. L. New or rare microfungi. *Trans. Brit. Myc. Soc.* 6: 149–157. 1919.
66. — & C. Rea. Fungi new to Britain. *Trans. Brit. Myc. Soc.* 2: 31–40. 1903.
67. Sommerstorff, H. Ein Tiere fangender Pilz (*Zoöphagus insidians*, nov. gen., nov. spec.). *Oesterr. Bot. Zeits.* 61: 361–373. 1911.
68. —. Pflanzliche Bestien. *Mitt. Naturw. Ver. Univ. Wien.* 10: 37–39. 1912.
69. Stehli, G. Pflanzen auf Insektenfang. 79 p. 1934.
70. Vanha, J. Die mährische landwirthschaftliche Landes-Versuchsanstalt in Brünn in der Zeit des ersten Jahrzehntes ihrer Tätigkeit vom Jahre 1899 bis 1910. *Zeits. Landw. Versuchsw. Oesterreich* 14: 597–633. 1911.
71. Woronin, M. *Sphaeria Lemnaceae, Sordaria coprophila, fimiseda, Arthrobotrys oligospora*. In Bary, A. de & M. Woronin. *Beitr. Morph. Physiol. Pilze. III. Abhandl. Senckenbergische naturf. Ges.* 7: 325–360. 1870.
72. Zopf, W. Zur Kenntniss der Infections-Krankheiten neiderer Thiere und Pflanzen. *Nova Acta Leop.-Carol. Deut. Acad. Naturf.* 52: 314–376. 1888.
73. —. Die Pilze in morphologischer, physiologischer, biologischer und systematischer Richtung. In Schenck, *Handbuch der Botanik* 4: 271–755. 1890.

EXPLANATION OF FIGURES

Fig. 1. *Arthrobotrys superba*; drawn with the aid of a camera lucida at a uniform magnification; $\times 500$ throughout. A, Portion of hypha with two small predacious systems: one, a, consisting of two anastomosing balls; the other, b, of five elements, whereof three have anastomosed and two are still in course of elongation. B, Portion of hypha with a moderately well developed predacious network. C, Portion of mycelium with a specimen of

Rhabditis dolichura Schneider captured without hyphal involvement by adhesion on the external surface of the simple loop, from which, following perforation of the integument, a bulbous outgrowth has been intruded into the animal to give rise to branching hyphae extending to the head; the posterior part of the animal being similarly occupied by hyphae extended from a second bulbous outgrowth intruded directly from the undifferentiated axial filament. *D*, Portion of mycelium with a moderately well developed predacious network in which have been captured through both adhesion and involvement a specimen of *R. dolichura*; the nematode being occupied by hyphae arising from two bulbous outgrowths that were intruded by one of the elements in the network through perforations in the integument. *E*, A branched conidiophore bearing conidia at successive nodes. *F*, A simple conidiophore, showing conidia borne at 9 successive nodes, each node marking the apex of a geniculation. *G*, *H*, *I*, Denuded conidiophores. *J*, *a-z*, Conidia, showing variations in size and shape; *d*, representing a somewhat rare 2-septate specimen; *f* and *t*, specimens of unusual length.

Fig. 2. *Arthrobotrys cladodes*; drawn with the aid of a camera lucida at a uniform magnification; $\times 500$ throughout. *A*, Portion of wide storage hypha from old maize meal agar plate culture. *B*, *C*, Predacious networks of anastomosing hyphal bails. *D*, Network in which a specimen of *Rhabditis dolichura* has been captured by entanglement and adhesion, then invaded by hyphae from two bulbous bodies intruded by the fungus. *E*, Network with a specimen of *R. dolichura* captured by adhesion on the external surface; the nematode having been invaded by assimilative hyphae from three globose bodies intruded by the fungus. *F*, Conidiophore with a conidial head on the main axis, and also on a lateral branch. *G*, Portion of hypha with two conidiophores, one bearing conidial heads on the axial termination, *b*, and the lateral branches *a* and *c*; the other, *d*, unbranched, and bearing a single, terminal head. *H*, Segment of mycelial hypha, showing origin close together of two denuded conidiophores. *I*, *a-g*, Tips of denuded conidiophores, showing distribution of sporiferous protuberances, as well as variations in size and shape. *J*, *a-z*, Conidia, showing variations in size and shape.

Fig. 3. *Arthrobotrys oligospora*; drawn with the aid of a camera lucida at a uniform magnification; $\times 500$ throughout. *A-D*, Portions of mycelium, each with a predacious network. *E-G*, Predacious reticula in each of which has been captured through adhesion and entanglement a specimen of *Rhabditis dolichura*; the nematodes are being invaded by filaments arising from bulbous structures intruded by the fungus, the numbers of such structures present in the captives being two, two and four respectively. *H*, Portion of superficial hypha whereon are borne a small network and a conidiophore with a terminal conidial head; from a nematode-infested culture. *I*, Portion of hypha bearing a conidiophore with two conidial clusters; from a nematode-infested culture. *J*, Distal portion of denuded conidiophore showing arrangement of spore-bearing protuberances in four successive nodes. *K*, Distal portion of denuded conidiophore showing variations in number and arrangement of protuberances in six successive nodes. *L*, Conidia showing variations in size, shape and septation: *a*, *c*, *d*, *g*, *i*, *k*, *m*, *n*, from nematode-infested culture; *b*, *e*, *f*, *h*, *j*, *l*, *o-z*, from pure culture on maize meal agar, the 2-septate condition represented in *v* and *w* being unusual. *M*, A germinating conidium, on the germ tube of which a small predacious loop has been

formed. *N*, Portion of hypha from old culture, with three chlamydospores, *a*, *b* and *c*. *O*, Portion of hypha from old culture with two chlamydospores, *a* and *b*.

Fig. 4. *Arthrobotrys conoides*; drawn with the aid of a camera lucida at a uniform magnification; $\times 500$ throughout. *A*, *B*, Portions of mycelium, each with a predacious network. *C*, A predacious network whereby has been captured mostly through adhesion a small larva probably referable to *Acrobeloides bütschlii* (De Man) Thorne; the animal is being invaded by hyphae from three globose bodies intruded by the fungus. *D*, A predacious loop in which has been captured by entanglement and adhesion a more mature nematode referable to *A. bütschlii*; the interior of the captive has been invaded by hyphae from the two globose bodies intruded by the fungus. *E*, Conidiophore with a single compact terminal head of conidia. *F*, Conidiophore with three looser clusters of conidia; the lowermost cluster is much closer to the base than is usual for the species. *G*, Denuded conidiophore showing arrangement of conidiiferous protuberances on the somewhat coralloid fertile tip. *H*, Denuded conidiophore with three nodes, showing variations in number of sporiferous protuberances on each node, and in distance between successive nodes; the lowermost node here, also, occurring at relatively short distance from base. *I*, *a-z*, Conidia, showing variations in dimensions and shape and in position of septum. *J*, Portion of a wide storage filament in an old culture. *K-O*, Chlamydospores from a culture 20 days old, showing variations in size and shape and in relationship to parent hypha.

Fig. 5. *Arthrobotrys musiformis*; drawn with the aid of a camera lucida at a uniform magnification; $\times 500$ throughout. *A*, Portion of mycelium bearing two simple predacious loops, *a* and *b*, and a small network, *c*. *B*, Portion of hypha with two loops, one, *a*, having caught no prey, the other, *b*, encircling a small nematode probably referable to *Rhabditis dolichura*, whose contents have been largely absorbed by the two hyphae extending from the bulbous part intruded soon after capture. *C*, Portion of hypha with two fused loops; on the outer surface of the proximal loop a somewhat larger nematode, *Diploscapter coronatus* (Cobb) Cobb, has been captured through adhesion, killed by intrusion of a bulbous outgrowth, and invaded by two assimilative filaments. *D*, Conidiophore and conidia. *E*, Two conidiophores arising a short distance apart and from the same vegetative filament, one, *a*, showing 13 conidia attached in a well developed head, the other, *b*, denuded. *F*, Portion of hypha, showing two fused predacious loops, *a*, and a denuded conidiophore, *b*, whereon had been borne 15 conidia. *G*, *H*, *I*, Tips of denuded conidiophores, showing variations in length and arrangement of spore-bearing spurs. *J*, *a-z*, Conidia, showing variations in dimensions, in shape, and in position of septum. *K*, Germinating conidium. *L*, Group of six conidia that have become fused through vegetative anastomosis of germ tubes. *M-R*, Chlamydospores produced on filaments submerged in the substratum, showing separation of wall into inner and outer layers, and variations in size, in shape and in relationship to mycelium. *S*, *T*, Chlamydospores formed in conidia which had become fused to mycelial hyphae.

Fig. 6. *Arthrobotrys dactyloides*; drawn with the aid of a camera lucida at a uniform magnification; $\times 500$ throughout. *A*, Portion of hypha with a constricting ring turned flatways to show relationship of component cells.

B, Portion of hypha with two constricting rings, *a* and *b*, turned from normal position by animals infesting the culture. *C*, Portion of hypha with three constricting rings, *a-c*, in their normal positions, as viewed looking down into substratum. *D*, A captured specimen of *Acrobelloides bütschlii* killed through constriction of a predacious ring, from the swollen cells of which have been intruded globose bodies that have given rise to assimilative hyphae, each terminating in a bulbous enlargement. *E*, A small specimen of *A. bütschlii* captured in two predacious rings, and killed through their constriction; the swollen cells of the rings having thereupon penetrated the integument and extended through the fleshy interior a number of assimilative hyphae, each terminating in a bulbous enlargement. *F*, A conidiophore arising from a prostrate hypha and bearing seven conidia in a terminal head. *G*, A conidiophore bearing 13 conidia, a relatively large number, in a somewhat compound head. *H*, Denuded conidiophore with a short branch whereon had been attached a number of conidia in an accessory head at some distance from the main terminal head. *I*, A conidiophore that after becoming denuded had declined to the substratum, and there become fused with germ tubes from three conidia. *J*, *a-z*, *aa*, *bb*, Conidia of the uniseptate dactyloid type usually produced by the fungus. *K*, Conidium that has germinated by the production of a small predacious ring.

Fig. 7. *Dactylella bembicodes*; drawn with the aid of a camera lucida at a uniform magnification; $\times 500$ throughout. *A*, Portion of hypha with two predacious rings, *a* and *b*, in normal position as viewed looking down into substratum. *B-E*, Portions of hypha, each bearing a predacious ring in approximately normal position, as viewed looking down into substratum. *F-H*, Portions of hypha, each with a predacious ring turned from normal position by passing animals, showing variation in structure of predacious organs. *I*, A captured specimen of *Plectus parvus* Bastian evidently at point of death as result of constriction, previous to invasion of interior by the fungus. *J*, A specimen of *P. parvus* killed by constriction and partly invaded by hyphae arising from the swollen cells of the closed ring. *K*, A specimen of *P. parvus* constricted by two rings from each of which assimilative hyphae have been extended into the fleshy interior. *L*, A captured specimen of *Rhabditis dolichura* invaded throughout by hyphae arising from the swollen cells of the closed ring; the animal's contents having been largely absorbed, the integument has begun to collapse by flattening out here and buckling there. *M*, A part of mycelial hypha with the basal portion of an old conidiophore, *a*, from which has arisen a young fertile hypha, *b*, that is expanding at the tip to form a conidium. *N*, A portion of vegetative hypha with a predacious ring, *a*; also, arising from it, a conidiophore, *b*, bearing the mature terminal conidium, *c*, and a young secondary conidiophore, *d*. *O*, A portion of hypha with a mature denuded conidiophore. *P*, *a-z*, Conidia, showing variations in size, shape and septation. *Q*, A conidium giving rise to an erect conidiophore. *R*, A conidium germinating by the production of two germ tubes.

Fig. 8. *Dactylella ellipsospora*; drawn with the aid of a camera lucida at a uniform magnification; $\times 500$ throughout. *A-G*, Portions of mycelial hyphae, each bearing on stalks two predacious adhesive knobs, *a* and *b*. *H*, A portion of hypha with two predacious stalked knobs, *a* and *b*; on the knob,

b, a small specimen of *Plectus communis* Bütschli has been captured through adhesion, its integument penetrated, and its fleshy interior invaded first by a bulbous mortiferous structure and then by a longitudinal assimilative filament. *I*, Portion of mycelium with two predacious stalks, *a* and *b*; on *b* a larva of *P. parvus* has been captured through adhesion, its integument perforated, and its fleshy interior invaded first by a mortiferous bulbous structure, then by two longitudinal assimilative filaments. *J*, A portion of mycelium with five predacious adhesive knobs, *a-e*; three of the knobs, *c-e*, have participated in the capture of a nematode belonging probably to *Cephalobus* sp., each having penetrated the animal's integument, then intruded a globose structure and assimilative filaments. *K*, A portion of mycelial hypha with four predacious knobs, *a-d*; on *d* a nematode of the same species as the one in *J* has been captured; after perforation of the integument and intrusion of a globose structure, three assimilative hyphae have been extended into the fleshy interior. *L-R*, Conidiophores arising from mycelial hyphae, or, as in *L* and *Q*, from basal portions of older conidiophores that have declined to the substratum; each bearing a single terminal conidium. *S*, *a-s*, Conidia, showing variations in size, shape and septation. *T*, Conidium germinating by the production of two polar germ tubes. *U*, Conidium giving rise to an erect conidiophore.

Fig. 9. *Dactylella asthenopaga*; drawn with the aid of a camera lucida at a uniform magnification; $\times 500$ throughout. *A*, Portion of hypha fused with the germ tube from a conidium, and showing six stalked predacious knobs. *B*, Portion of mycelium with two stalked predacious knobs. *C*, Portion of mycelium with three predacious knobs, two being empty and collapsed, the other functional by having intruded into a captured specimen of *Bunonema* sp., a globose body from which two hyphae are growing into the fleshy interior. *D*, Portion of hypha with two predacious knobs, on one of which a specimen of *Bunonema* sp. has been captured; the animal, after being killed through intrusion of a globose body, having been invaded by assimilative hyphae. *E*, Portion of hypha with two degenerated predacious knobs in addition to one on which a specimen of *Bunonema* sp. has been captured; the nematode after being killed through the intrusion of a globose body having been invaded by an assimilative filament. *F*, Two hyphae each bearing two predacious knobs that have collaborated in the capture of two specimens of *Bunonema* sp.; the animals, *a* and *b*, each having been paralyzed by the simultaneous intrusion of two globose bodies and then invaded further by assimilative hyphae arising therefrom. *G*, Hypha bearing two predacious knobs and a conidiophore with conidium. *H-J*, Conidiophores, each bearing a single conidium. *K*, Branched conidiophore bearing two conidia. *L*, Branched conidiophore bearing three conidia. *M*, *a-s*, Conidia showing variations in size, shape and septation. *N*, *a-e*, Conidia that have germinated by producing one or two stalked adhesive knobs. *O*, Conidium that has given rise at its distal end to two predacious knobs, at its proximal end to a vegetative hypha; on one of the two predacious knobs is attached the depleted integument of a captured specimen of *Bunonema* sp.; on the vegetative hyphae are borne predacious knobs, only one of which is shown.

Fig. 10. *Dactylella lysipaga*; drawn with the aid of a camera lucida at a uniform magnification; $\times 500$ throughout. *A*, A predacious ring. *B*, A

predacious ring and a knob arising from the same stalk. *C*, Two rings of separate origins, one, *a*, having fused distally with the distal cell of the other, *b*. *D*, Portion of hypha with two predacious rings. *E*, A predacious ring. *F*, A portion of mycelium with two stalked knobs, *a* and *b*, and a ring, *c*. *G*, A portion of mycelium with two stalked knobs, *a* and *b*; two reciprocally conjoined rings, *c* and *d*; *c* having fused with the distal cell of *d*, and *d* having fused with the proximal segment of *c*; and a discrete ring, *e*. *H*, A predacious ring. *I*, *J*, Rings just previous to fusion of tip with proximal segment. *K*, Portion of mycelium with a collapsed knob, *a*; a normal knob, *b*; and a ring, *c*. *L-N*, Predacious rings, showing variations in size, shape and length of supporting stalk. *O*, Hypha growing out of caudal end of nematode, with four rings attached to it. *P*, Living specimen of *Rhabditis dolichura* encircled by eight predacious rings, as found two days after the transfer of large slabs from an agar plate culture of the fungus to an agar plate culture abundantly infested with nematodes; some of the rings have become loosened with incipient molting of the integument, and none yet appear to have penetrated into the animal. *Q*, Specimen of *R. dolichura* occupied by assimilative hyphae intruded from an encircling ring; the ring having subsequently given rise externally to five hyphae, *a-e*, of which two, *c* and *d*, bear predacious apparatus. *R*, Conidiophore terminating in an immature conidium. *S*, Portion of mycelium with two conidiophores, *a* and *b*, arising close to one another. *T*, Conidiophore bearing two conidia, one at the tip of the main axis, the other on a spur arising a short distance below the tip. *U*, A denuded branched conidiophore. *V*, *a-z*, Conidia, showing variations in size, shape and septation. *W*, Conidium germinating by production of two delicate conidiophores. *X*, Conidium that has given rise to a conidiophore with a secondary conidium. *Y*, *Z*, Conidia, each germinating vegetatively by production of two polar germ tubes.

Fig. 11. *Dactylella leptospora*; drawn with the aid of a camera lucida at a uniform magnification; $\times 500$ throughout. *A*, Two hyphae emerging from an opening in the integument of an invaded specimen of *Rhabditis dolichura*; showing two stages in the development of a predacious ring, a very early stage, *a*, and a somewhat later stage, *b*. *B*, Hypha with one ring, *a*, in process of development, and three completed rings, *b*, *c*, *d*. *C*, Two hyphae emerging from a break in the integument of an infected specimen of *R. dolichura*; on them are shown attached five completed rings, *a-e*. *D-F*, Predacious rings, showing variations in size and shape, and in length of supporting stalk. *G*, Specimen of *R. dolichura* encircled by seven rings, *a-g*, three of which, *c*, *e*, and *f*, have each perforated the integument and intruded a bursiform excrescence. *H*, Specimen of *R. dolichura* killed by the fungus, showing the animal's body occupied by assimilative hyphae, five branches of which, *a*, *b*, *d*, *e*, and *f*, have broken through the integument to produce further predacious organs outside; such organs have been produced also on another hypha, *c*, which grew out of one of the encircling rings. *I*, Portion of hypha from pure culture, whereon have arisen three conidiophores, *a*, *b* and *c*, shown with conidia attached. *J*, Branched conidiophore with two conidia. *K*, Branched conidiophore denuded of its spores. *L*, A short, simple, denuded conidiophore. *M*, *a-c*, Conidia from pure culture, without any external development. *N*, *a-k*, Conidia from pure culture that have

given rise to predacious knobs. *O*, Two conidia from a pure culture, joined through vegetative fusion. *P*, Conidium from pure culture, that has given rise to three conidiophores, *a*, *b*, and *c*, each bearing a secondary conidium. *Q*, Conidium from a pure culture; it has given rise to an apical globose cell, to a simple conidiophore, *a*, bearing a single secondary conidium, and to a branched conidiophore, *b*, whereon are borne three secondary conidia. *R*, Conidium from pure culture; it has given rise laterally to a stalked globose cell, and to a somewhat tall conidiophore bearing a secondary conidium. *S*, *a-h*, Secondary conidia showing variations in size, shape and septation. *T*, *a-d*, Conidia from nematode-infested agar plate culture, showing variations in size, shape and septation.

Fig. 12. *Dactylella geophyropaga*; drawn with the aid of a camera lucida at a uniform magnification; $\times 500$ throughout. *A*, Portion of hypha, showing seven adhesive columnar branches. *B*, Portion of hypha with three columnar processes, two being joined by an arched connection, the other about to become similarly joined. *C*, Portion of mycelium with a connected series of hyphal meshes formed through the bridging over of nine adhesive processes spaced at fairly regular intervals; and showing, besides, two isolated arches of similar origin. *D*, Portion of hypha with a predacious network formed through the development of bridging connections between neighboring columnar processes; enmeshed in and adhering to the network is a specimen of *Plectus communis*, whose body is being invaded by hyphae arising from a globose protuberance intruded by the fungus immediately after perforation of the integument. *E*, Portion of mycelium with a more irregular network and a specimen of *Acroboloides bütschlii* captured through adhesion and enmeshment, which is being occupied by assimilative hyphae from five separate globose bodies intruded by the fungus. *F*, A conidiophore terminating in a young conidium. *G*, A conidiophore at a somewhat later stage, the young conidium here being set off by a septum. *H*, A conidiophore at a still later stage, the young conidium being now divided by a single septum. *I*, A conidiophore with a fully developed 4-septate conidium; a secondary conidiophore is beginning to grow out of the basal cell. *J*, A denuded conidiophore of moderate stature,—taller specimens, more frequently produced, not being shown for lack of space. *K*, *a-w*, Conidia, showing variations in size, shape and septation.

Fig. 13. *Dactylaria brochopaga*; drawn with the aid of a camera lucida at a uniform magnification; $\times 500$ throughout. *A*, An early stage in the development of a constricting ring. *B*, A portion of hypha in lateral aspect, showing four constricting rings, *a-d*, edgewise. *C*, Portion of hypha with two open constricting rings, *a* and *b*, turned sideways by passing animals, and a closed ring, *c*, likewise turned sideways; showing cellular relationships in ring and in stalk. *D*, Portion of hypha with five closed rings, *a-e*, in four of which, *a-d*, specimens of *Diploscapter coronatus* (Cobb) Cobb have been captured; the other, *e*, having contracted apparently as the result of being lashed by the animals caught in *b* and *c*. *E*, Portion of hypha with a ring wherein a specimen of *Acroboloides bütschlii* has been captured; the assimilative hyphae later extended through the animal each terminating in an enlargement. *F*, Portion of superficial filament from which arise two conidiophores, *a* and *b*, bearing seven and six conidia respectively, in well

defined terminal heads. *G*, Portion of mycelium with a conidiophore bearing 12 conidia—a greater number than is usual—in a well defined terminal head. *H*, A denuded conidiophore of ordinary stature. *I*, Portion of hypha bearing three unusually short denuded conidiophores, *a-c*, as found sometimes in pure cultures on maize meal agar. *J*, Terminal portions of denuded conidiophores, *a-e* showing the closer and more characteristic arrangement of sporiferous protuberances in fertile hyphae developed in nematode-infested agar plate culture, as compared with the extended arrangement, *f-j*, revealed by fertile hyphae produced in pure culture on maize meal agar. *K*, Conidia showing variations with respect to size, shape, and septation, in two strains,—*a-m* being from a strain with relatively small spores, *n-s* from a strain with larger spores. *L*, Conidium with a curving process that represents an early stage in the formation of a constricting ring. *M-P*, Conidia, each of which has germinated by giving rise to a predacious ring.

Fig. 14. *Dactylaria thaumasias*; drawn with the aid of a camera lucida at a uniform magnification; $\times 500$ throughout. *A*, Portion of hypha with four predacious bails compounded into a small network. *B*, Portion of hypha with a more extensive network consisting of a dozen hyphal bails. *C*, Portion of hypha with a predacious network wherein has been ensnared a large specimen of *Rhabditis* sp.; through perforations in the animal's integument have been intruded three bulbous protuberances, of which two are giving rise to assimilative hyphae. *D*, A conidiophore bearing fourteen conidia in a relatively loose, somewhat racemose head; the three septa in each conidium being arranged in the manner most typical of the species. *E*, A conidiophore arising from the same hypha as *D*, and bearing in more compact capitate arrangement 11 conidia similarly partitioned in the manner most typical of the species. *F-J*, Conidia less typical of the species with respect to shape and to number and distribution of cross-walls. *K*, Conidium germinating by production of two germ tubes, one from the apex, the other from a place adjacent to the base. *L*, Anastomosis of two germinating conidia. *M-P*, Apical parts of denuded conidiophores, showing variations in arrangement of the stubby sterigmata on the main axis or on lateral branches. *Q-S*, Chlamydo-spores, showing their structure as well as their relationship to the parent hypha.

Fig. 15. *Dactylaria candida*; drawn with the aid of a camera lucida at a uniform magnification; $\times 500$ throughout. *A*, Portions of hypha of varying lengths—three short ones, *a-c*, each bearing a stalked predacious knob; a longer one, *d*, bearing two stalked knobs; another, *e*, still longer, bearing three such knobs. *B*, Portion of hypha with a predacious ring in an early stage of development. *C*, Portion of hypha with a stalked predacious ring in a later stage of development, shortly preceding fusion of the tip with the widened proximal cell. *D-G*, Portions of hyphae, each bearing a predacious ring; showing variations in shape, size and cellular structure. *H-J*, Portions of hypha on which stalked predacious knobs and predacious rings are borne in close proximity to one another. *K*, Portion of hypha bearing a stalked ring wherein has been ensnared and held a specimen of *Plectus parvus*. *L*, A large female specimen of *Diploscapter coronatus* that except for the sculptured egg within it, is occupied throughout by assimilative hyphae intruded from the ring encircling the animal near the head; as the four fila-

ments attached to the ring are manifestly all mycelial elements newly developed from materials supplied by the assimilative hyphae, the predacious organ must have been pulled from its supporting stalk and been carried about until the animal succumbed to hyphal invasion. *M, N, O*, Conidiophores bearing eight, five, and six conidia respectively. *P-T*, Denuded conidiophores showing differences in dimensions, septation, and attachment of the spore-bearing sterigmata. *U, a-d*, Terminal portions of conidiophores, showing variations in diameter and in arrangement of spore-bearing sterigmata. *V, a-z, W, a-p*, Conidia showing variations in size, shape and septation. *X*, A conidium germinating by the production of an erect aerial filament, later to develop into a conidiophore.

Fig. 16. *Dactylaria polycephala*; drawn with the aid of a camera lucida at a uniform magnification; $\times 500$ throughout. *A*, Portion of hypha bearing a predacious network relatively small for the species. *B*, Portion of hypha with a somewhat more extensive predacious network. *C*, Portion of mycelium with an extensive network resulting from the union of two predacious reticula that began development separately. *D, E*, Predacious networks in each of which a specimen of *Rhabditis dolichura* has been captured; following narrow perforation of the integument of each animal, a bulbous outgrowth was intruded, from which assimilative hyphae have grown lengthwise through the fleshy interior. *F*, Portion of mycelium bearing a conidiophore with successive conidial heads. *G*, Portion of mycelium with a denuded conidiophore, showing the distribution of sterigmatic warts on the slightly swollen sporiferous nodes. *H, a-u*, Conidia showing variations in size, shape, and septation. *I*, Conidium germinating normally by the production of two polar germ tubes. *J*, Four germinating conidia that have become united through vegetative anastomosis.

Fig. 17. *Triposporina aphanopaga*; drawn with the aid of a camera lucida at a uniform magnification; $\times 500$ throughout. *A-E*, Portions of mycelium, showing penetration of fungus into specimens of *Plectus communis*, intrusion of a slightly swollen body, and extension of assimilative hyphae lengthwise through the fleshy interior. *F*, Portion of mycelium with two branches, *a*, that have invaded a specimen of *P. communis*, and a conidiophore bearing a conidium not only on its primary axis, *b*, but on a lateral branch, *c*, as well. *G*, A conidiophore with a conidium in early stage of development. *H*, A conidiophore with mature conidium; some distance from its base a branch or secondary conidiophore has begun to develop. *I-O*, Mature conidia in lateral view, showing variations in size, shape and septation. *P, Q, R*, Mature conidia as seen looking down on the distal surface; the 12 partitions delimiting 13 segments in *P* and *Q* are representative of full septation in the species. *S*, An early stage in the development of a conidium.

Fig. 18. Drawn with the aid of a camera lucida at a uniform magnification; $\times 500$ throughout, except in *R, a*.

A-E, Trichothecium polybrochum: *A*, Portion of hypha with three constricting rings, *a-c*, viewed from above in positions in which they were produced. *B*, A constricting ring turned sideways to show cellular structure of noose and stalk. *C*, Portion of mycelium with a predacious ring wherein a nematode has been captured and compressed to death. *D*, A conidiophore bearing a single conidium. *E*, Three fallen conidia, *a-c*, one, *c*, in early

stage of germination; showing the large upper cell of each enveloped in a layer of hyaline mucus.

F-H, Dactylella tenuis: *F, G*, Portions of hypha from each of which arises a conidiophore bearing a single 3-septate conidium. *H, a-u*, Conidia showing variations in size, shape and septation.

I-K, Arthrobotrys dactyloides: *I*, Portion of mycelium showing vegetative fusions with two inflated conidia, *a* and *d*, as well as with two digitate conidia, *b* and *c*. *J*, Portion of hypha fused vegetatively with a digitate uniseptate conidium, *a*, and with a swollen 2-septate conidium, *b*. *K, a-p*, Conidia from a culture infested with mites, showing varying degrees of inflation as well as variations in number and position of the cross-walls.

L, Dactylaria thaumasia. Conidia: *a*, with three partitions arranged in the manner most usual in the species; *b-e*, with two septa spaced as in many of the swollen conidia of *Arthrobotrys dactyloides*; *f*, with four cross-walls delimiting three small proximal cells, a large penultimate cell, and a small distal cell.

M, Dactylella gephyropaga. Portion of mycelium with adhesive processes, on one of which a specimen of the testaceous rhizopod *Trinema enchelys* was captured; an assimilative hypha then having been intruded at the unprotected mouth into the protoplasmic interior of the animal.

N, Dactylella bembicodes. Portion of mycelium bearing a predacious ring in which a rotifer has been captured and constricted to death.

O-Q, Dactylella rhombospora: *O*, Portion of mycelium with an erect conidiophore bearing a single conidium. *P*, A relatively short, denuded conidiophore. *Q, a-n*, Conidia, showing variations in size, shape and septation.

R, A small ascomycete found developing in a maize meal agar plate culture abundantly infested with nematodes and with *Arthrobotrys superba*: *a*, Median section of apothecium, $\times 10$; *b-d*, asci, showing variations in shape and size as well as in arrangement of the 8 tear-shaped ascospores.

NOTES AND BRIEF ARTICLES

The honorary degree of doctor of laws was conferred on Professor W. P. Fraser by the University of Saskatchewan at its May Convocation in recognition of his pioneer work on Canadian plant diseases, especially for his endeavours in the campaign against wheat rust, both as personal contributions and as the "respected leader . . . of a band of enthusiastic pupils and disciples," and, as the outstanding authority on the native Prairie flora. Professor Fraser has retired from active teaching after almost two decades of service, but will continue his association with the University, working mainly on his herbarium collections.

MYCOLOGICAL SOCIETY OF AMERICA

SUMMER FORAY

The Summer Foray will be held at Dartmouth College, Hanover, New Hampshire, August 26-28 inclusive. Doctor A. H. Chivers of the Biology Department of that institution will be in charge of local arrangements. He has arranged for the use of dormitory facilities on the campus, for which a charge of \$5.00 will be made for the three-day period, or at the rate of \$2.00 per day for periods less than the full three days. Dining facilities either on or off the campus will be available. Headquarters will be in the Biology Building (Silsby Hall). Reservations for dormitory quarters should be made through the Office of the Bursar, Mr. Max Norton, Dartmouth College. For those who prefer different quarters the Hanover Inn has been recommended, but advance reservations should be made. Room rates are quoted at \$3.50-\$4.00 single (with bath) and \$5.50-\$6.00 double (with bath). It is hoped that eastern and New England mycologists will make a special effort to attend this gathering; all who are interested in Mycology, whether members of the Society or not, are urged to attend.

FUNGI EXSICCATI SUECICI, PRAESERTIM UPSALIENSES

With the above title there is now in progress, under the editorship of Seth Lundell and J. A. Nannfeldt, a most outstanding series of fungi exsiccati. This project was inaugurated by the Elias Fries Committee formed in December 1933 for the purpose of issuing an exsiccatum of Swedish fungi, with particular reference to those occurring in the region of Upsala where Elias Fries collected for so many years. The committee was composed of Prof. N. E. Svedelius, J. A. Nannfeldt, and other prominent Swedish botanists with the assistance of Mr. Seth Lundell. As would be expected the fungi included in the series have been to a considerable extent Hymenomycetes collected and named by Mr. Lundell, a specialist in the group and pupil of the late Lars Romell. Other groups including Discomycetes are the work of Dr. Nannfeldt. Eight fascicles of 50 numbers each have been issued to date and the exsiccatum is planned to include a total of at least 500 numbers. It is being distributed through the Botanical Institute of the University of Upsala to nine mycological herbaria in Europe and one in America.

This series of fungi exsiccati deserves particular mention not only because of the historical region mycologically from which the specimens are taken, but because of the care with which the material has been collected, preserved and packeted. The individual specimens are ample in all cases, and have been packeted in double folders for complete protection. The Agaricaceae included have been prepared by a new process originated by Mr. Lundell which has done much to preserve colors and other diagnostic characters in this group so difficult to handle as herbarium specimens. Altogether these specimens constitute a most unusual series, and one that will become of increasing interest and importance with the passing of the years.—JOHN A. STEVENSON.

FLORA AGARICINA DANICA

The second volume of this Iconograph by the well known Danish mycologist Jakob E. Lange has recently appeared. The work is being published under the auspices of the Society for the Ad-

vancement of Mycology in Denmark and the Danish Botanical Society. The first volume appeared in 1935. Although the author has confined himself to the Agaricaceae of Denmark, his work is indispensable to critical students of the family in the United States and Canada. Many of the curious and unusual species which Dr. Lange has discovered are widely distributed and are to be found both in eastern North America and along the Pacific Coast. The work is outstanding because all the species recognized in the Danish flora are described and illustrated. An unusually high degree of accuracy has been obtained in depicting and reproducing the natural colors and fine details in each species. There are keys to all the species and brief descriptions which emphasize the characters the author considers important.

The first volume consists of the genera *Amanita*, *Limacella*, *Lepiota*, *Armillaria*, *Tricholoma* and *Clitocybe*. The genus *Amanita* is divided into two subgenera, *Eu-Amanita* and *Amanitopsis*. Thirteen species are recognized. *Limacella* is represented by one species, *L. lenticularis*. The genus *Lepiota* is divided into three subgenera, *Eu-Lepiota*, *Leucobolbitius* and *Cystoderma*. Forty-three species are treated. In *Armillaria* four species are included. *Tricholoma* is divided into two subgenera, *Eu-Tricholoma* and *Dermoloma*. Sixty-one species are recognized, one of which is placed in *Dermoloma*. *Clitocybe* is divided into two subgenera, *Eu-Clitocybe* and *Laccaria*. Forty-eight species are recognized in the Danish flora.

In the second volume are *Collybia*, *Marasmius*, *Mycena*, *Omphalia*, *Panus*, *Volvaria*, *Pluteus* and *Rhodophyllus*. *Collybia* is divided into two subgenera, *Mucidula* with one species and *Eu-Collybia* with thirty-one. *Marasmius* is divided into *Eu-Marasmius* with twenty-one species and *Crinipellis* with one. *Mycena* is divided into *Eu-Mycena* with fifty-seven species and *Mycenella* with two. *Omphalia* is represented by thirty-four species, *Pleurotus* with twenty, *Panus* with three, *Volvaria* with eight and *Pluteus* with sixteen species. The genus *Rhodophyllus* is divided into five subgenera, *Entoloma* with eighteen species, *Leptonia* with eight, *Nolanea* with twelve, *Eccilia* with eight and *Claudopus* with one species.

The taxonomic treatment is conservative and most of the older generic names are retained. This adds greatly to the general usefulness of the work. The treatment of the old genera *Entoloma*, *Nolanea*, *Leptonia*, *Eccilia* and *Claudopus* as a single genus *Rhodophyllus* will doubtless meet with certain objections, but does have much to recommend it from a practical standpoint. The arrangement of the species in *Eu-Mycena* is highly artificial.

The nomenclature is not strictly in accordance with the present accepted international code, and certain of the names used are not tenable under any code. *Mycena pseudogalericulata* Lange, 1914, is untenable because of the existence of *Mycena pseudogalericulata* Pat. 1897. Since Maire has given Lange's species the name *Mycena Jacobi* (1930), it is rather unfortunate that the latter name was not used in Lange's latest work. Because of the confusion which exists in the recognition of species in the Agaricaceae it is not surprising to find certain species concepts in Lange's work over which there is a difference of opinion. *Mycena plicosa* var. *marginata* Lange for instance is a distinct species for which the oldest valid name is apparently *Mycena capillaripes* Peck. *Mycena pinetorum* Lange is identical with the robust form of *Mycena latifolia* Peck. Certain inconsistencies are also to be noted: *Mycena fellea* Lange is arranged in the subgroup Exsuccae between *Mycena iris* and *Mycena alcalina* and the suggestion is made that *Mycena cholea* Smith is hardly specifically distinct. *M. cholea* possesses a milky juice similar to that of *Mycena galopoda* and cannot therefore be correctly arranged in a section of non-latex producing species—where Lange places his *M. fellea*. The comments under the description of *Mycena sepia* Lange are also misleading, since the most recent study of Peck's species, *Mycena atroalboides*, has shown that the latter has cystidia of the echinulate-roughened type. Such errors as these are practically inevitable in a group where little authentic material exists and the literature is widely scattered. They do not detract materially from the value of the work as a whole. There is little doubt that Lange's Agaricina Danica will always remain one of the outstanding contributions to Agaricology.—ALEXANDER H. SMITH.

MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOL. XXIX SEPTEMBER-OCTOBER, 1937

No. 5

PRODUCTION OF CONIDIA BY *CORTICIUM* INCRUSTANS¹

MILDRED K. NOBLES²

(WITH 26 FIGURES)

This species, under the name *Corticium roseopallens* Burt, was studied by Lyman (1907) who described the characteristics displayed by the fungus in culture, with special emphasis on the production of conidia. When in the course of a study of conidia-bearing species of Thelephoraceae, cultures of this species were obtained, it seemed desirable to repeat his observations and extend them where possible.

Rogers (1935) found that the American *Corticium roseopallens* Burt was identical with the European *Corticium incrustans* v. Höhn. & Litsch. Since the latter name has priority, it is adopted here.

The fruit body from which the cultures were obtained was collected by Dr. R. F. Cain on a log of *Populus* sp. near Hatchley, Ontario, on October 27, 1934 (University of Toronto Herbarium No. 6549).

¹ Contribution from the Department of Botany, University of Toronto, Toronto, Ontario.

² The author wishes to acknowledge her indebtedness to Professor H. S. Jackson, under whose direction the work was carried on, and to Dr. R. F. Cain, who collected the fruit body from which the cultures were obtained.

[MYCOLOGIA for July-August (29: 377-556) was issued August 2, 1937]

CULTURAL STUDIES

Haploid mycelium. The basidiospores, which are hyaline allantoid bodies ranging from $4-5 \times 1.5-2.5 \mu$ in size, germinate readily when sown on malt extract agar, the sporelings being large enough to transfer to stock culture tubes in forty-eight hours. According to Lyman (1907) the basidiospores retain their viabil-

| | | A | | | | | | | | | | | | | | | | | a | | | | | | | | | | |
|----|----|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|---|---|----|----|----|----|----|----|----|
| | | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 13 | 14 | 15 | 17 | 18 | 19 | 20 | 24 | 27 | 28 | 1 | 2 | 11 | 16 | 21 | 22 | 23 | 25 | 26 |
| A | 3 | | | | | | | | | | | | | | | | | | | | + | + | + | + | + | + | + | + | + |
| | 4 | | | | | | | | | | | | | | | | | | | | + | + | + | + | + | + | + | + | + |
| | 5 | | | | | | | | | | | | | | | | | | | | + | + | + | + | + | + | + | + | + |
| | 6 | | | | | | | | | | | | | | | | | | | | + | + | + | + | + | + | + | + | + |
| | 7 | | | | | | | | | | | | | | | | | | | | + | + | + | + | + | + | + | + | + |
| | 8 | | | | | | | | | | | | | | | | | | | | + | + | + | + | + | + | + | + | + |
| | 9 | | | | | | | | | | | | | | | | | | | | + | + | + | + | + | + | + | + | + |
| | 10 | | | | | | | | | | | | | | | | | | | | + | + | + | + | + | + | + | + | + |
| | 12 | | | | | | | | | | | | | | | | | | | | + | + | + | + | + | + | + | + | + |
| | 13 | | | | | | | | | | | | | | | | | | | | + | + | + | + | + | + | + | + | + |
| | 14 | | | | | | | | | | | | | | | | | | | | + | + | + | + | + | + | + | + | + |
| | 15 | | | | | | | | | | | | | | | | | | | | + | + | + | + | + | + | + | + | + |
| | 17 | | | | | | | | | | | | | | | | | | | | + | + | + | + | + | + | + | + | + |
| | 18 | | | | | | | | | | | | | | | | | | | | + | + | + | + | + | + | + | + | + |
| | 19 | | | | | | | | | | | | | | | | | | | | + | + | + | + | + | + | + | + | + |
| 20 | | | | | | | | | | | | | | | | | | | | + | + | + | + | + | + | + | + | + | |
| 24 | | | | | | | | | | | | | | | | | | | | + | + | + | + | + | + | + | + | + | |
| 27 | | | | | | | | | | | | | | | | | | | | + | + | + | + | + | + | + | + | + | |
| 28 | | | | | | | | | | | | | | | | | | | | + | + | + | + | + | + | + | + | + | |
| a | 1 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | | | | | | | | | |
| | 2 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | | | | | | | | | |
| | | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | | | | | | | | | |
| | 16 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | | | | | | | | | |
| | 21 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | | | | | | | | | |
| | 22 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | | | | | | | | | |
| | 23 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | | | | | | | | | |
| | 25 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | | | | | | | | | |
| | 26 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | | | | | | | | | |

FIG. 1. *Corticium incrustans*. Results obtained by pairing in all possible combinations twenty-eight mycelia, each derived from the germination of a single basidiospore.

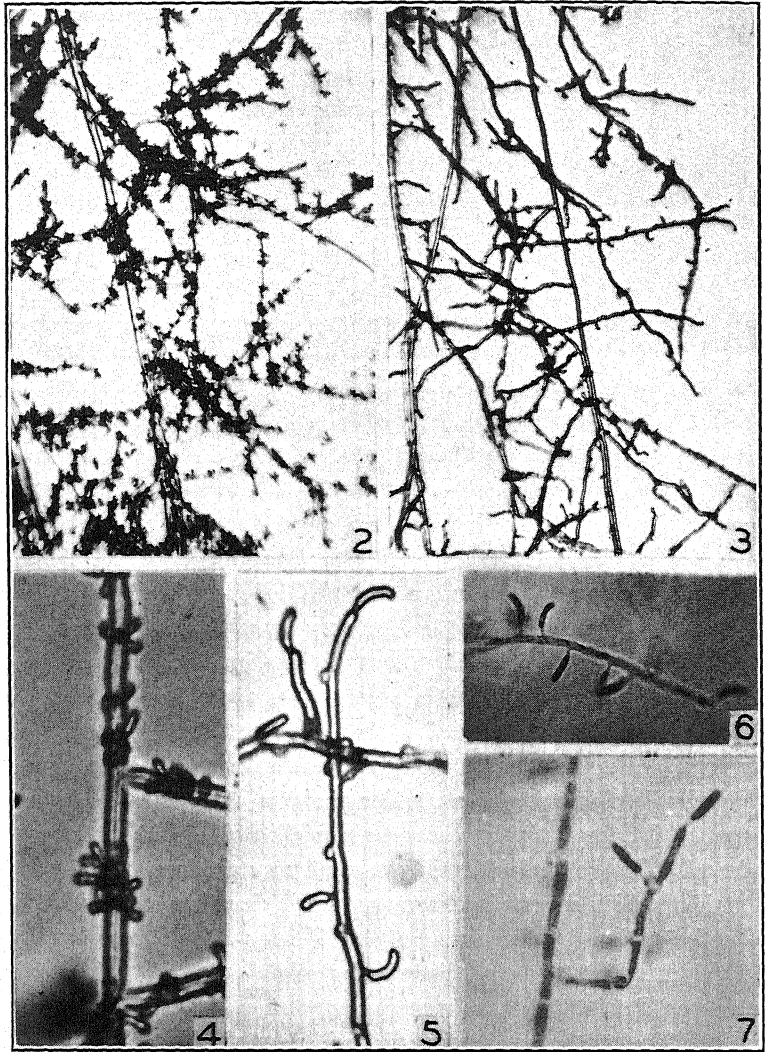
ity for a considerable length of time, up to six months under laboratory conditions, but this has not been verified in the present work.

When grown on malt extract agar the mycelium arising from a single basidiospore is slow-growing, with most of the hyphae sub-

merged or appressed so that the colony appears rather soggy or damp. After some days a slight growth of aerial hyphae develops, which becomes denser with age. Usually the mycelium is white, although in some cultures it has a pale pink color. Microscopic examination shows that the hyphae have simple septa. Lyman (1907, *pl. 20, fig. 61*) stated that the basidiospores were irregular in their behavior, germinating to produce mycelium bearing clamp connections in some cases, lacking them in others. This led Martens and Vandendries (1933) to conclude that the fungus is homothallic, a conclusion which has not been corroborated in the present work, where clamp connections were never observed on sporelings arising from basidiospores. Furthermore, of the thirty single basidiospores isolated, none has developed clamp connections in the two years since their isolation. Hence it must be concluded that monosporous mycelia of *Corticium incrustans* are haploid.

Conidia. About five days after the germination of a basidiospore, the colony begins to produce conidia (FIG. 2, 4, 6). They resemble the basidiospores in that they are allantoid and hyaline, but they exceed the basidiospores slightly in size, ranging from 5.0–8.9 μ in length by 1.9–3.0 μ in width, averaging $7.1 \times 2.3 \mu$. Their production is confined to aerial hyphae. The formation of a conidium is initiated by the appearance of a papilla on a hypha, the papilla elongating to a slender sterigma, the end of which increases in size until the characteristic allantoid conidium is produced. On the haploid mycelium a cell may produce one to many conidia, which appear in clumps on small elevations or in whorls. In the moist chambers devised by Vernon (1931) the hyphae which grow into the air, bristle with conidia (FIG. 2). Older cultures on Petri dishes have a similar appearance when viewed under a lens, due to the production of conidia on all the aerial hyphae. These conidia give rise to haploid mycelia indistinguishable from those of basidiospore origin.

Pairings of single basidiospore cultures. Two months after their isolation, twenty-eight of the single basidiospore cultures were grown together in pairs in all possible combinations, and the resulting mycelia examined for the presence of clamp connections. The data so obtained are tabulated in figure 1, in which a plus



FIGS. 2-7. Production of conidia. 2, haploid mycelium and conidia, grown in Vernon cell, $\times 150$ approximately; 3, diploid mycelium and conidia, $\times 200$ approximately; 4, haploid mycelium and conidia, $\times 600$ approximately; 5, diploid mycelium and conidia, $\times 600$ approximately; 6, conidia on haploid hypha, $\times 500$ approximately; 7, conidia on diploid hypha, $\times 500$ approximately.

sign indicates the presence of clamp connections, a minus sign their absence. It may be observed that the mycelia fall into two groups, a member of group *A* reacting with a member of group *a* in such a way as to produce a clamp-bearing mycelium, but failing to respond in such a manner to a member of the same group. Hence *Corticium incrustans* is heterothallic and of the bipolar type of interfertility.

Diploid mycelium. The character of the growth of the diploid mycelium obtained by pairing two suitable haploid mycelia, resembles that of the parent haploid mycelia in general, but differs in being more vigorous both in rate of growth and production of aerial hyphae. Microscopically the diploid mycelium differs in the presence of a clamp connection at every septum, and in the less abundant production of conidia. The conidia borne on the diploid mycelium are similar to those of haploid origin in general appearance, but exceed them in size, being $7.6\text{--}13.2 \times 2.5\text{--}3.8 \mu$, averaging $10.8 \times 3.1 \mu$. These conidia are produced in the same way as the haploid conidia, but, except in rare instances, there is only one conidium on each cell (FIG. 3, 5, 7). Quite frequently a conidium is borne directly on a clamp connection (FIG. 7). The spores may be close together along a hypha but careful observation shows the presence of only one on each cell. Following conidium formation the cell becomes vacuolate, and seemingly never regains sufficient vigor to produce a second spore. In general, conidia which were developed on a clamp-bearing mycelium germinate to give sporelings showing clamp connections immediately.

CYTOLOGICAL STUDIES

A cytological study has been made of haploid and diploid mycelium, conidia, and sporelings. Although the small size of nuclei in rapidly growing hyphae caused considerable difficulty in observations, it is possible to make definite statements about most of the points of interest.

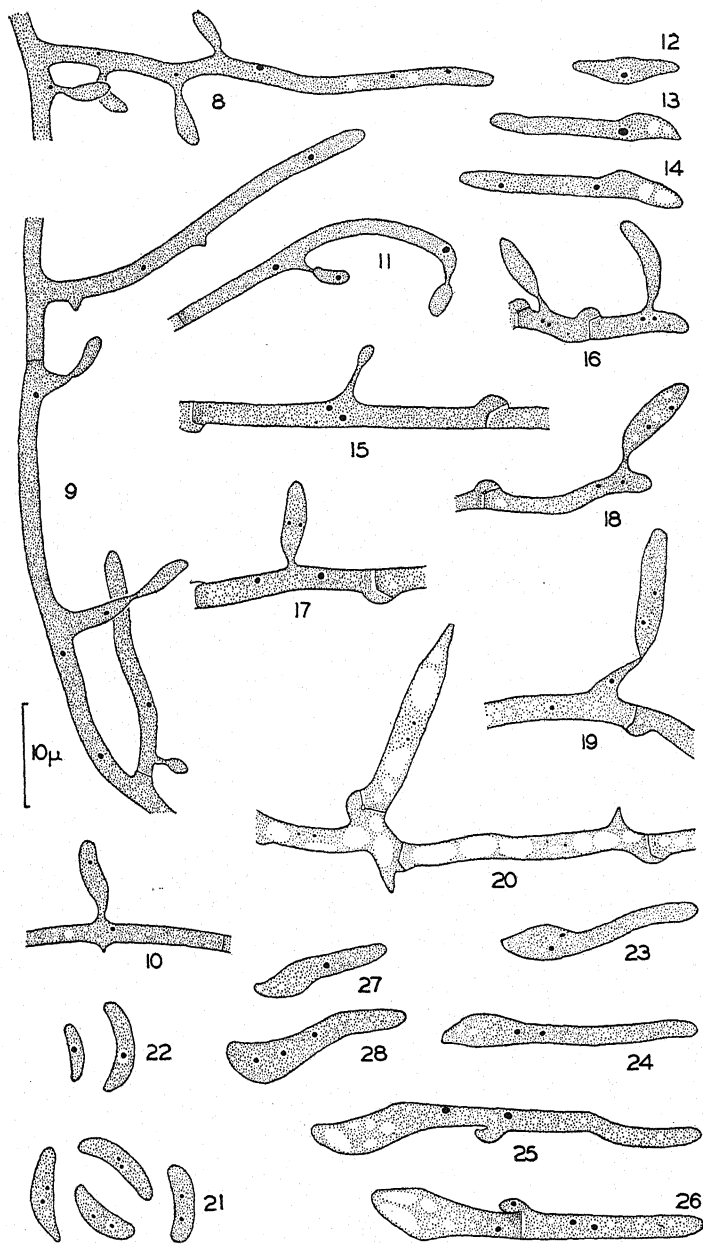
Haploid mycelium. In a haploid mycelium, those cells which are at some distance back from an actively growing hyphal tip are uninucleate, while tip cells and those directly behind the tip are usually long and contain from two to several nuclei spaced at in-

tervals along the cell (FIG. 8, 9). Hence in growing mycelium, septum formation does not follow directly on nuclear divisions, nor does it appear to be associated with these divisions.

Conidia. Conidia are formed on hyphae whose contents show an affinity for stain. The sterigma originates at any point on the cell wall, without reference to the nuclei within the cell (FIG. 8, 9), but before the conidium attains full size, a nucleus is seen at the base of the sterigma (FIG. 8, 9). It is inferred that this nucleus divides, since later stages show a nucleus in the spore, and one within the cell below the spore (FIG. 10, 11). That this occurs is substantiated by the observation of whorls of conidia on a cell. The nuclei of these spores probably originate in the successive divisions of one nucleus, one daughter nucleus migrating into each spore, one remaining in the hypha. Stages in the germination of haploid conidia are illustrated in figures 12-14.

Diploid mycelium. The mycelium bearing clamp connections consists of binucleate cells, the nuclear divisions taking place through the agency of the clamp connections. Conidia are produced at any point on the cell wall or on the clamp connection. As in the haploid mycelium a conidium appears first as a small tapering outgrowth, the end of which swells to form the spore (FIG. 15). When the latter has reached a considerable size, the two nuclei are to be seen at the base of the sterigma (FIG. 16). Although division figures have not been observed, it is assumed that these nuclei undergo a division without the intervention of a clamp connection, since later stages show a binucleate conidium continuous with a cell which is still binucleate (FIG. 17, 18). Following the production of conidia, the cells become vacuolate, and the contents gradually lose their affinity for the stain (FIG. 19, 20).

Vandendries (1934b) has described a comparable condition in *Pleurotus pinsitus*, in which conidia are produced on dicaryotic mycelium in a manner resembling that in *Corticium incrustans*. In *P. pinsitus* the usual course is for the two nuclei of the parent cell to migrate into the conidium. He writes (p. 208) "Une conidie latérale, placée entre deux anses d'anastomose, reçoit les deux noyaux de l'article mycélien qui la porte. Ce tronçon limité aux deux extrémités par des cloisons placées aux anses d'anastomose, perd ainsi toute possibilité de vie. On constate dans les



FIGS. 8-26. Cytological studies. 8-11, haploid hyphae and stages in conidium formation; 12-14, stages in germination of haploid conidia; 15-19, stages in formation of conidia by binucleate cells; 20, diploid cells following formation of conidia; 21, binucleate conidia produced on diploid mycelium; 22, uninucleate conidia produced on diploid mycelium; 23-26, stages in germination of binucleate conidia; 27, 28, germination of conidia containing irregular members of nuclei. All $\times 1400$.

préparations des filaments ainsi énucléés et porteurs, entre deux boucles, d'une conidie binucléée." Occasionally Vandendries observed that the nuclei divided, and one pair entered the spore, the cell remaining binucleate. In either case, the formation of a conidium apparently leaves the cell in a weakened condition from which it never recovers, and in this respect *Pleurotus pinsitus* is similar to *Corticium incrustans*.

In describing the formation of conidia on diploid mycelium of *Corticium incrustans*, it was stated that each conidium receives two nuclei (FIG. 21). In general such is the case. Occasionally, however, conidia containing irregular numbers of nuclei were observed in stained preparations (FIG. 22). Of 131 stained conidia counted, 110 or 83.9 per cent were binucleate; 17 or 12.9 per cent were uninucleate, while 3 contained three nuclei and 1 contained four nuclei. Examination of stained preparations has not shown how these one-, three- and four-nucleate spores have formed. It is conceivable, however, that a conidium produced on a clamp connection might receive only the nucleus of the clamp-cell, which had failed to migrate into the penultimate cell following a division. Since many conidia are observed on clamps, this might explain the occurrence of the uninucleate spores. Formation of a spore on a clamp connection might also result in the production of a spore containing three nuclei, if, following nuclear division, the wall cutting off the clamp connection failed to form, and the two nuclei of the end cell, along with the nucleus of the clamp connection, migrated into the conidium. Finally the four-nucleate conidium might arise through the failure of a clamp connection to function in a nuclear division, or by migration of both daughter nuclei of a division preceding conidium formation. Unfortunately these are only suggestions without observations to substantiate them.

In the germination of conidia from a dicaryotic mycelium, the two nuclei of the spore migrate into the germ tube (FIG. 23-26) where the first division is accomplished through the agency of a clamp connection, and thereafter the mycelium is composed of binucleate cells, and indistinguishable from that resulting from the pairing of two compatible haploid mycelia. The few uninucleate conidia produced on the diploid mycelium germinate tardily to

form mycelia like those arising from single basidiospores. In *Pleurotus pinsitus*, Vandendries (1934b) found occasional uninucleate conidia on diploid mycelium, but never observed the germination of these. Kaufert (1935) described the production of spores in conidia on haploid and diploid cultures of *Pleurotus corticatus*. Of the spores formed on the diploid mycelium, the majority contained two nuclei, but a few contained only a single nucleus. It would appear that such uninucleate spores are exceptional and of slight importance in the life of the fungus.

DISCUSSION

Corticium incrustans is the first species of the Thelephoraceae in which the existence of both haploid and diploid conidia has been established. That these were produced was indicated by Lyman's (1907) figures and descriptions, in which he stated that (p. 176) "the germ tubes (of conidia) may or may not bear clamps." The present study has shown that conidia borne on haploid or diploid mycelium repeat the generation on which they are produced.

For a long time diploid spores have been known to occur in rusts and smuts, but their production by a hymenomycetous species has been reported only rarely. Martens and Vandendries (1933) reviewed the literature on the subject and concluded (p. 351) "Il n'existe qu'un très petit nombre d'exemples où l'origine et la valeur diploïde des spores accessoires soient réellement établies." Since that time the production of binucleate conidia has been described in five species: *Pholiota aurivella* by Martens and Vandendries (1933); *Trametes cinnabarina* by Vandendries (1934a); *Pleurotus pinsitus* by Vandendries (1934b); *Polyporus squamosus* by Vandendries (1934c); *Polyporus corticatus* by Kaufert (1935). The present study has added a sixth species to this list.

SUMMARY

Corticium incrustans v. Hohn. & Litsch. is heterothallic and of the bipolar type of interfertility. Conidia are produced on short sterigmata on vegetative hyphae. In haploid mycelium several uninucleate conidia are borne on each cell. These germinate

readily to give rise to new individuals like the parent. In diploid mycelium, one conidium is borne on each cell. These spores are binucleate and give, on germination, new diploid plants.

DIVISION OF BOTANY,
CENTRAL EXPERIMENTAL FARM,
OTTAWA, ONTARIO

LITERATURE CITED

- Kaufert, F. The production of asexual spores by *Pleurotus corticatus*. *Mycologia* 27: 333-341. 1935.
- Lyman, G. R. Culture studies on polymorphism of Hymenomycetes. *Proc. Boston Soc. Nat. Hist.* 33: 125-209. 1907.
- Martens, P. & Vandendries, R. Le cycle conidien haploïde et diploïde, chez *Pholiota aurivella*. *La Cellule* 41: 337-386. 1933.
- Rogers, D. P. Notes on the lower Basidiomycetes. *Univ. Iowa Studies Nat. Hist.* 17: 1-43. 1935.
- Vandendries, R. Contribution a l'étude de la sexualité dans le genre *Trametes*. *Bull. Soc. Myc. Fr.* 50: 98-110. 1934a.
- . La polarité sexuelle et le régime conidien chez *Pleurotus pinsitus*. *Ibid.* 50: 203-212. 1934b.
- . Les polarités sexuelles dans le genre *Pholiota*. *Ibid.* 50: 270-277. 1934c.
- Vernon, T. R. An improved type of moist chamber for studying fungal growth. *Ann. Bot.* 45: 733-737. 1931.

THE CULTURAL CHARACTERISTICS OF *FOMES CONNATUS*¹

W. A. CAMPBELL

(WITH 2 FIGURES)

INTRODUCTION

In a study of the cultural characteristics of the species of *Fomes*,² the writer tried without success to secure *Fomes connatus* (Weinm.) Gill. in pure culture. As Baxter (2) has noted, sporophore tissue isolations are difficult to obtain because the soft, watery sporophores, even when very young, are contaminated by other fungi and bacteria. It is also difficult to isolate from the soft rot produced by *F. connatus* due to the rather constant association of discoloring organisms with its incipient stages. Many attempts were made over a period of two years to isolate the fungus from fresh sporophores and decayed wood and to germinate the basidiospores. These were unsuccessful because of the presence of contaminating fungi or the failure of the spores to germinate. Finally a sporophore was collected which produced viable spores free from contaminants. The fungus, so obtained, was believed to be *F. connatus*, but because of the number of conflicting organisms previously secured, additional spore cultures were deemed essential before any cultural study of the species could be made.

A knowledge of the cultural characteristics of *F. connatus* became increasingly desirable in connection with decay studies in northern hardwoods, since both *Acer Saccharum* and *A. rubrum*, important constituents of these stands, are common hosts for the fungus. During the fall of 1936 a fungus was isolated from a hard maple decay sample sent to Ross W. Davidson, of the Division of Forest Pathology, from the Kane Experimental Forest,

¹ Research supported in part by Emergency Conservation Work.

² Campbell, W. A. The cultural characteristics of the species of *Fomes*. Unpublished thesis. Pennsylvania State College 1935.

Pennsylvania, and was identified as *F. connatus* on the basis of a sporophore which it produced in culture. Field records showed that the tree from which the decay sample was obtained had *F. connatus* fruiting on it. Later, Davidson germinated spores obtained from a sporophore collected on *A. Negundo* by Campbell and Overholts at Haun's Bridge, Pennsylvania. These two isolations, whose Forest Pathology reference collection numbers are 71522 and 71339 respectively, proved identical in culture and agreed with the spore isolation obtained several years previously. The cultural characteristics of *F. connatus* as here given are based on these isolations.

FOMES CONNATUS IN CULTURE

*Petri dish cultures:*³ Growth very slow forming a mat about 1-2 cm. in diameter in 7 days. Mat white, cottony over inoculum, nearly colorless, thin, short cottony to fine woolly on agar proper; margin colorless to faintly white, thin, even.

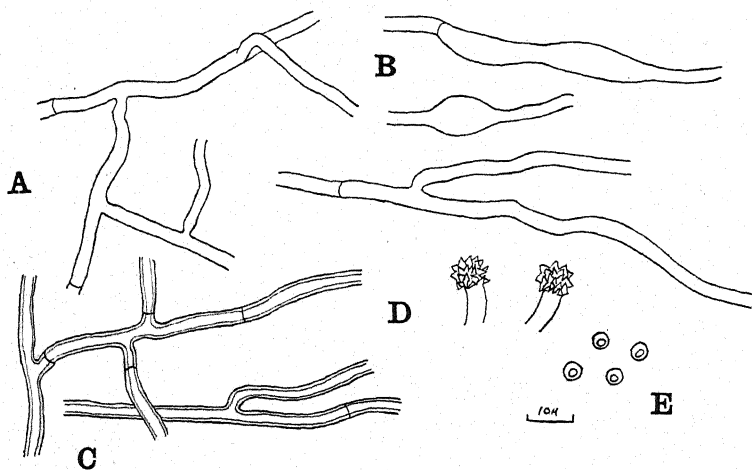


FIG. 1. *A*, submerged hyphae; *B*, swollen cells; *C*, fibrous hyphae from old cultures; *D*, incrusted cystidia from sporophore produced in culture; *E*, basidiospores produced in culture.

³ All descriptions based on mats grown on 1.5 per cent Difco malt with 2 per cent agar, in diffused light at room temperature, inoculum 2 mm. square.

In 14 days forming a mat 2-3 cm. in diameter (FIG. 2, *A*). Mat usually raised cottony over inoculum becoming more appressed cottony toward margin, very fragile, azonate, occasionally with prominent sectors.

Submerged hyphae 2-5 μ in diameter, very thin-walled, often much contorted and twisted, with abundant cross-walls but no

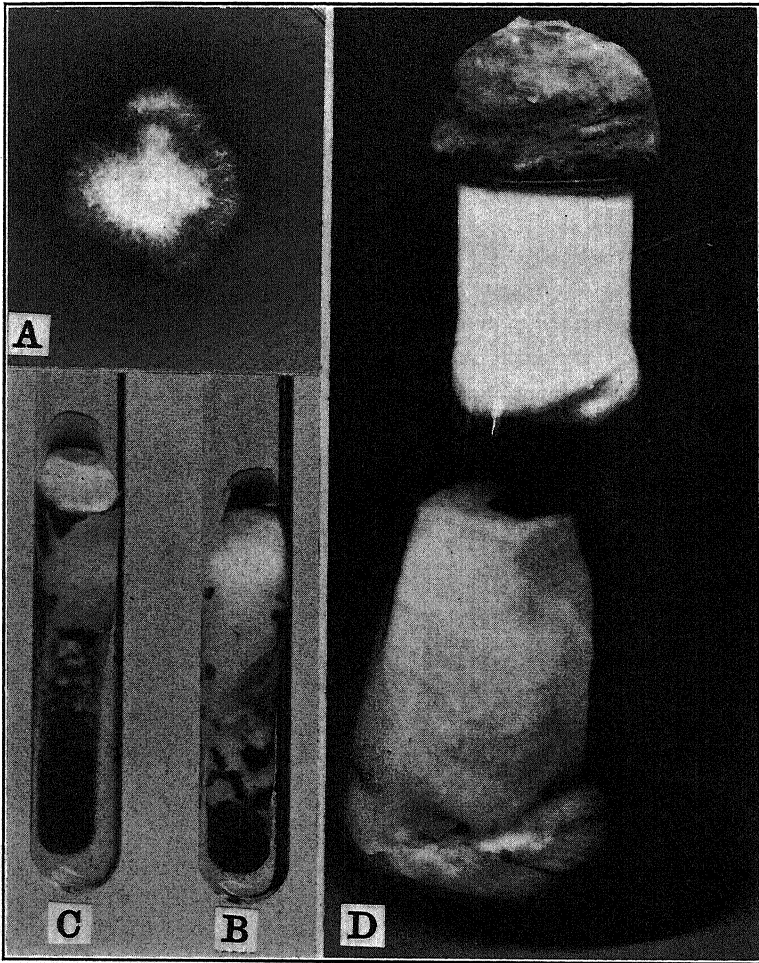


FIG. 2. *A*, mat age 14 days in Petri dish; *B*, age 28 days; *C*, isolation 71522 fruiting in tube, age 6 weeks; *D*, flask culture on maple block, age 2 months. Photographs by M. L. F. Foubert.

clamps (FIG. 1, *A*), swollen cells either terminal or intercalary, common (FIG. 1, *B*); superficial hyphae either same as submerged, thin-walled, staining readily with eosin 2–5 μ or empty, non-staining; fibrous hyphae 2–4 μ non-staining, smooth, with moderately thick walls, rare in young cultures but common in old Petri dish and test tube cultures (FIG. 1, *C*).

Bavendamm's (1) oxidase reaction test⁴ gave a faint to moderately strong brown diffusion zone on gallic acid medium with no growth in 7 days; on tannic acid medium a faint diffusion zone with no growth.

Temperature relations: Optimum temperature for growth about 25° C. Average diameters of mats in 7 days, in dark, at constant temperatures as follows: 1.5 cm., 20°; 2.4 cm., 25°; 1.4 cm., 30°; no growth, 35°.

Test-tube cultures: In 14 days forming a raised, white, silky-cottony mound on agar slant with appressed, colorless, cottony marginal region on agar cylinder.

In 28 days with a pronounced white, raised, compacted cottony pad on slant and with an indeterminate, white cottony growth on agar cylinder (FIG. 2, *B*).

In 6 weeks isolation 71522 consistently produced a white well-defined poroid area on the mycelial pad which formed on slant (FIG. 2, *C*). This fruiting structure produced the capitate incrustated cystidia and the globose spores characteristic of *F. connatus* (3) (FIG. 1, *D* and *E*).

Remarks: *F. connatus* has been cultured on cornmeal, prune, potato-dextrose and 5 per cent malt agar in addition to regular 1.5 per cent malt agar. The best growth was secured on potato-dextrose and 5 per cent malt. The fungus seems to find conditions on agar media unfavorable and makes slow growth. On sterilized hard maple blocks in large mouth flasks, the fungus grew vigorously, completely covering the blocks with a dense, thick, cottony covering (FIG. 2, *D*). Due to slow growth on malt agar, ordinary cultural methods fail to isolate it satisfactorily from decayed wood

⁴ Gallic acid medium is prepared by the addition of 0.5 per cent gallic acid to ordinary malt agar; tannic acid medium by the addition of 0.5 per cent tannic acid. White rot fungi produce a brown diffusion zone under mat. Brown rot fungi form no diffusion zone.

since the presence of bacteria and other fungi results in the slow-growing *F. connatus* being rapidly overgrown.

DIVISION OF FOREST PATHOLOGY,
BUREAU OF PLANT INDUSTRY,
U. S. DEPT. OF AGRICULTURE,
WASHINGTON, D. C.

LITERATURE CITED

1. **Bavendamm, W.** 1928. Ueber das Vorkommen und den Nachweis von Oxydasen bei holzerstörenden Pilzen. Zeits. Pflanz. Schutz. 38: 257-276.
2. **Baxter, D. V.** 1925. The biology and pathology of some of the hardwood heart-rotting fungi. Am. Jour. Bot. 12: 522-552.
3. **Overholts, L. O.** 1935. Polyporaceae of Pennsylvania. Tech. Bull. 316. The Pennsylvania State College.

EIDAMELLA SPINOSA (MATRUCHOT AND DASSONVILLE) REFOUND

EDWARD D. DeLAMATER¹

(WITH 27 FIGURES)

INTRODUCTION

Matruchot and Dassonville (11) published their account of *Eidamella spinosa* in 1901 for the first and only time that this organism has been reported. In the spring of 1936 Dr. N. F. Conant of the Department of Bacteriology, Duke Medical College, gave to the writer a culture of an obviously gymnoascaceous fungus, which he had cultured from a fingernail while working at the Beth Israel Hospital in Boston in 1935. The fungus was at that time tentatively identified as *Eidamella spinosa* (Mat. & Dass.). Since then the organism has been extensively studied in this laboratory and compared with the very lucid description of the two original authors and with other members of the family Gymnoascaceae. Cultures of the original strain have not been available, but there can be no doubt of its identity with the fungus described as causing a skin condition in a dog in France in 1901, although certain minute differences are noticeable, as will be shown below. These are, however, taken to be within the limits of variation of the form, or as due to differences in observation.

Matruchot and Dassonville considered *Eidamella spinosa* to be a true dermatophyte, although they were unable to reproduce typical lesions by inoculation. They did, however, isolate it more than once from the original lesion. The writer has also been unable to produce typical ringworm lesions with the present cultures, even though he has attempted to inoculate both himself and guinea pigs. The fact, however, remains that this fungus, the two times that it has been found, has occurred in definitely pathological conditions. This fact along with the knowledge that to experimentally induce infection with ringworm fungi is very difficult, can be taken as highly suggestive, though by no means final. The

¹ From the Laboratory for Medical Mycology, Department of Dermatology, College of Physicians and Surgeons, Columbia University, New York City.

question whether *Eidamella spinosa* is truly a pathogen or only a facultative parasite is, then, still an open one.

Datta (4) reported a sexual organism which he found as a parasite on a dog in India, and with which he was able to repeat infection. The writer has not been able to obtain this account and has had to rely on a second-hand statement given by Gregory (10), who had seen only an abstract. The chief difference noted is that Datta's form, *Eidamella actoni*, produces many (more than 8) ascospores per ascus, whereas in *Eidamella spinosa* the ascospore number is constantly eight, as in most of the true Gymnoascaceae, although a very few cases of 4-spored asci have been noted in other forms studied (5).

Dr. C. W. Dodge (6) has placed *Eidamella spinosa* and *Gymnoascus setosus* as synonyms. The writer from his study of both these organisms in culture and from a preview of previous accounts can find no justifiable evidence to sustain Dodge in his action. Matruchot and Dassonville have elaborately and in most details correctly described their fungus and it compares with *G. setosus* only in the production of spines, which are quite dissimilar in the two organisms, according to the reports in the literature. The writer has as yet not been able to induce sexuality in *G. setosus* in culture, however, the asexual forms are widely dissimilar. There follows a brief comparative summary of the characters of the two organisms obtained from the literature of the older writers. It will be readily seen that these two fungi are not the same. *Gymnoascus setosus* probably lies near the type species, *G. Reessii* Baranetsky, and asexually is very like *G. ruber* from both of which *E. spinosa* is readily distinguishable.

GYMNOASCUS SETOSUS

Peridial hyphae:

- a. Thick-walled.
- b. Dark brown, opaque.
- c. Branches end in spines.

EIDAMELLA SPINOSA

Peridial hyphae:

- a. Thick-walled, strongly cutinized.
- b. Blue-black.
- c. Branches do not all end in spines.
- d. Branches form arborescences, forming a trellis about asci. Hyphal tips end in characteristic spirals, especially about asci.
Some tips fragile, hyaline.

GYMNOASCUS SETOSUS

Asci:

Spherical, 8-spored, colorless.
Not pediculate.

Ascospores:

Spindle-shaped.
Colorless.
Form conidia by budding.

Hyphae:

Do not anastomose.
Branch freely, septate.

Conidia:

Numerous.
Formed in verticillate manner,
chiefly in clumps at nodes, often
these increase by budding as in
G. ruber.
Chlamydospores.

Mycelium:

Colorless.

Sexual phase: (after Eidam)

Early coil same as in *Gymnoascus*
Reessii, details unknown.
Sexual stage brownish.

Fuseaux:

None formed.

EIDAMELLA SPINOSA

Asci:

3-4 μ wide by 6-7-10 μ long, colorless.
Strongly pediculate.

Ascospores:

Lemon shaped, 1.5 μ by 3 μ .
Colorless.
Form no conidia by budding.

Hyphae:

Do anastomose freely.
Much branched, septate.
In dry culture size variable, 1.5-4 μ .
In wet cultures size constant.

Conidia:

None formed.
No bud cells found.
Chlamydospores
Not enlarged (intercalary)
Or enlarged (terminal)
Form in old cultures by local
encystment of ordinary vegetative cells.

Mycelium:

On corneal colorless, no pigment formed.
On potato colorless, no pigment formed.
On Sabouraud's honey white, pigment formed (blood red).
On maltose (Sabouraud's) same.
On blood agar same.
On all five media the sexual stage appears black or grayish.

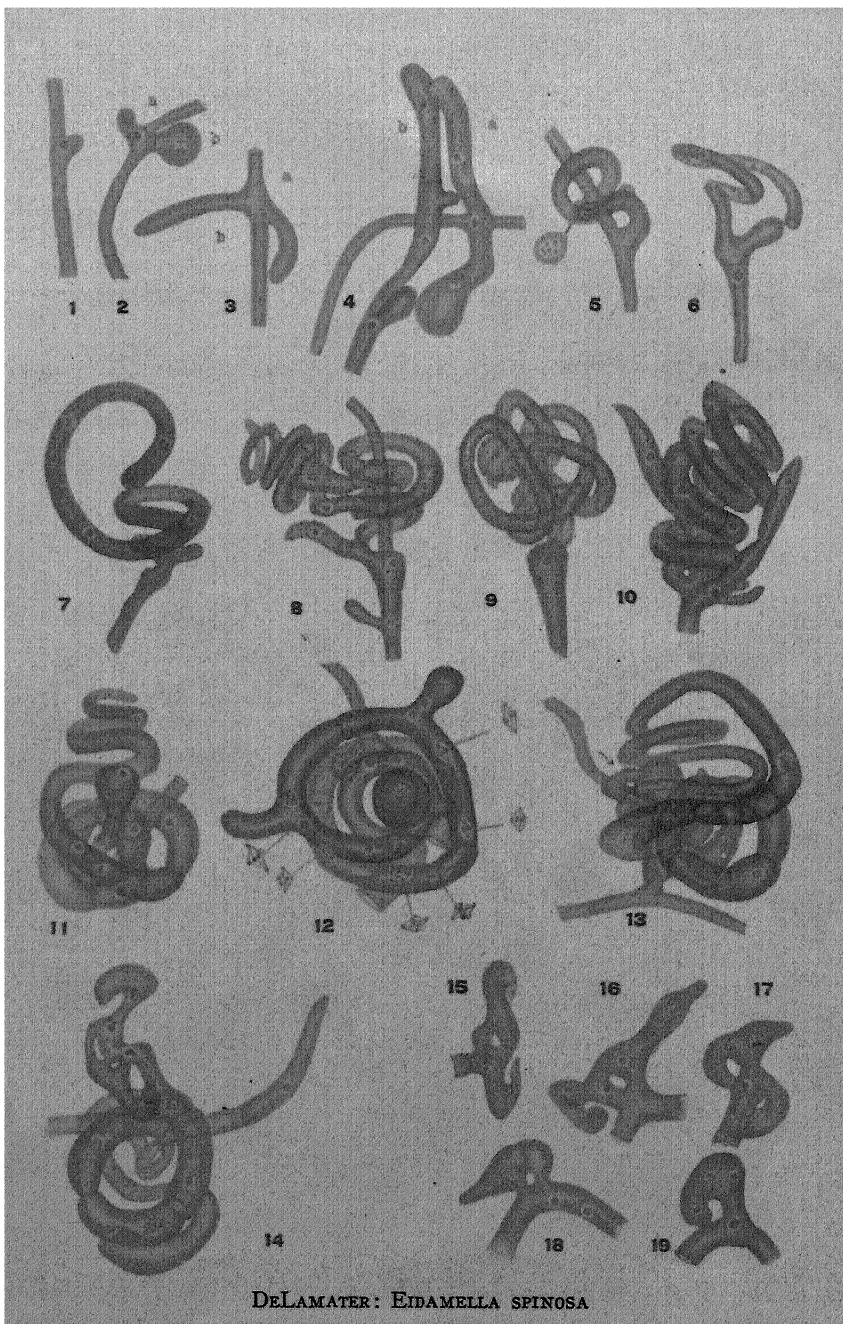
Sexual phase:

Sexual coil as in *Ctenomyces serratus*.

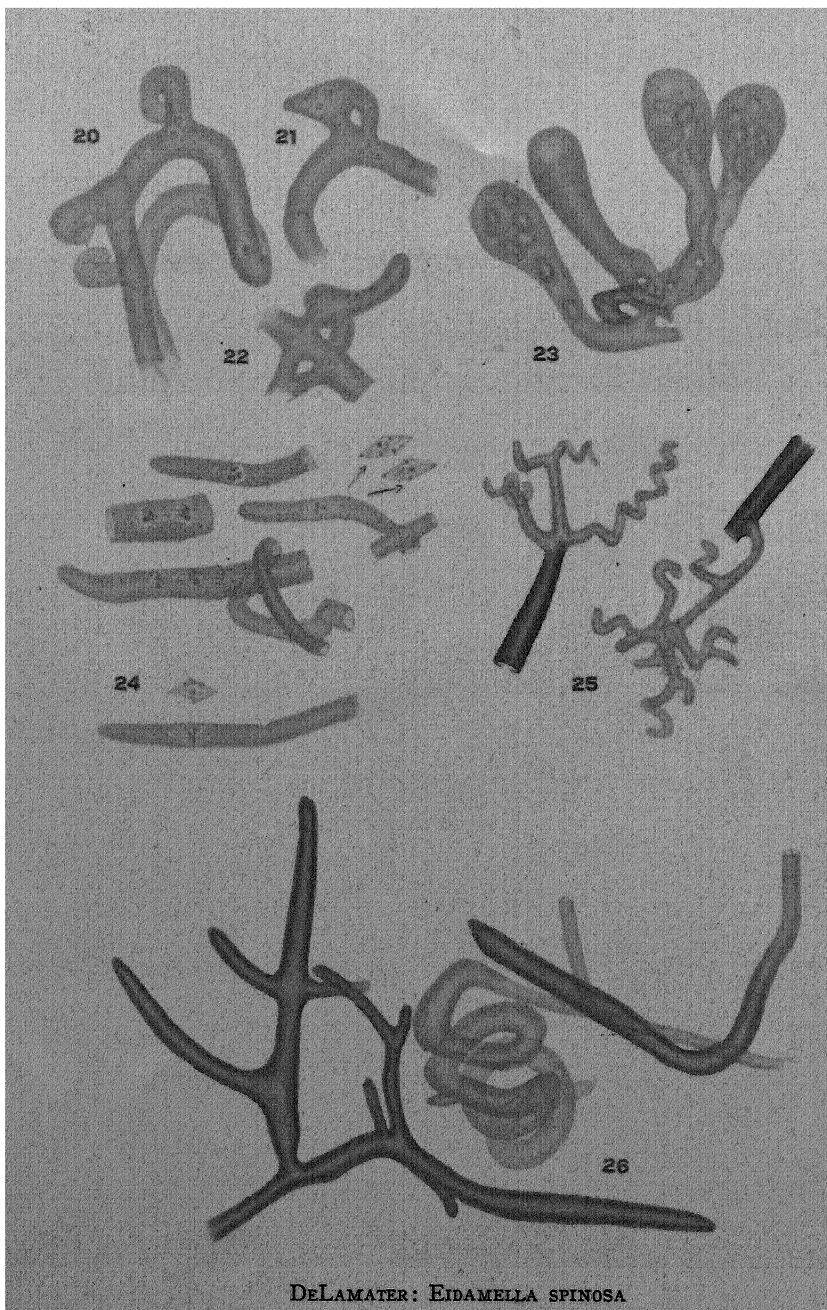
Fuseaux:

None formed.

The organism: This strain of *Eidamella spinosa* produces perithecia in abundance in all the culture media in which it has been grown, such as Sabouraud's honey and maltose agars, potato, cornmeal, and blood agar, etc. This is not true for the strain of *G. setosus* now in culture.



DeLAMATER: EIDAMELLA SPINOSA



DeLAMATER: EIDAMELLA SPINOSA

The asexual vegetative growth grossly resembles many of the true dermatophytes. However, microscopically no conidia of any sort are formed on any of the media. Thick-walled intercallary chlamydospores are, however, produced in large quantities, and less regularly terminal chlamydospores have been seen. Ascospores, then, and chlamydospores are the only types of reproductive bodies known. This fact was noted by the original authors. On the contrary in *G. setosus* abundant conidia of the verticillate type are produced, as noted by Dale (3) and others.

In culture on honey, maltose, and other agars, a very striking blood-red pigment is produced. It infuses the substrate, often completely coloring it. Only hyphae in contact with the substrate themselves become colored. This is what Matruchot and Dassonville called autopigmentation.

The mycelium is ordinarily pure white, except for the pigment as mentioned, and at the inception of the perithecial stage, when it becomes speckled with a gray-black appearance. On cornmeal and potato media the aerial growth is scant and the perithecia each stand out as minute, definite black specks against a white background. It was from such cultures that the permanent iron-alum haematoxylin mounts, drawings of which are shown here, were made (FIG. 1-26). Figure 27 is a photograph of these perithecia.

The mycelium is composed of abundantly branched, segmented hyphae which vary considerably in diameter in the aerial growth, but which, in the subaerial growth, are composed of hyphae the size of which is quite constant. The intercallary chlamydospores are approximately the same size as the hyphae; are thick walled, cylindric. They are not swollen as in many of the fungi and are formed apparently by the local encystment of hyphal cells. The terminal chlamydospores are not so thick walled and are considerably swollen; they occur in chains.

Sexual phase: Microscopically the perithecial fundiments appear as irregular coils, with or without knoblike central cells (FIG. 1-13). Although there is little regularity in the coiling of these structures in the early stages, the aspect of all is more or less similar. One questionable fusion between the central cell and coil has yet been observed, but the indications are that two adjacent cells of the coil itself fuse and the daughter nuclei from these cells

become associated, and subsequently give rise to ascogenous hyphae by typical crozier formation (FIG. 12, 14-23). These phenomena will be elaborated upon at a later time. Matruchot and Dassonville considered that the stages they observed recalled development of *Ctenomyces serratus* Eidam.

The hyphae forming the peridium of the perithecium arise both from the filament from which the coil originated, from the coil itself, and from the vegetative aerial hyphae surrounding the primordium of the future perithecium. The perithecium, then, is of compound origin. These peridial hyphae are easily recognizable, even in their very early stages, by their very characteristic shape and density. As they gradually reach maturity they become thick walled and of a dense blue-black under the microscope (FIG. 3, 4, 14, 24, 25, 26). They form about the young, developing coil a web of closely entwined hyphae, the outer extremities of which later become definitely spined (FIG. 26). Directly surrounding the ascogenous mass the branches of the thick, black protective hyphae end in clear hyaline coils instead of spines (FIG. 25). These vegetative peridial coils branch irregularly and form a dense protective trellis directly surrounding the ascogenous mass (asci). This multiple structure is very characteristic of the older perithecia, and form about the time the asci begin to enlarge. Some of the short lateral branches of these peridial hyphae do not form either spines or coils, but are thin walled, hyaline, with dense cytoplasm, and are very fragile. They seem to be growth centers by which the peridial hyphae increase in extent and complexity. They simulate closely the condition found in the rapidly growing younger stages, in which the walls have not yet begun to thicken.

The asci themselves are longly pediculate, and each contain eight oval spores. Both asci and spores are hyaline. The asci are more strikingly pediculate in this strain than in that studied and figured by the original authors for theirs, but they emphasized the presence of the condition and figured it. At rupture of the ascus the eight spores often adhere, apparently due to a cohesive mucilage, which holds them together.

Thirteen single ascospore cultures all produced perithecia in

which normal spores were found. This very definitely indicates that this fungus is hermaphroditic and self-fertile (homothallic), which has an interesting significance when one considers the work of Emmons (9) and DeLamater (5) in which nineteen species of Penicillaceae and three of the Gymnoascaceae were found to be hermaphrodite and self-fertile.

In this paper it is not desired to give a complete story of the development of this fungus, but rather to note that this interesting organism, which was so strongly emphasized by its original describers as a sexual form of one of the skin fungi, has been re-found and that although it has not as yet been proven pathogenic, it was at least, as in the original case, found in a definitely pathological condition. Whether it was the causative agent or not is another question, which is as yet unsettled. To date the animal inoculation work with the ringworm fungi has been largely unsatisfactory, and until a criterion of infectivity or infectiousness is obtained it will be difficult to establish not only this case but many which are today considered offhand as pathogenic.

The distribution of this fungus, the two times that it has been found, presents of itself an interesting problem. That the same fungus should be found first in France in a pathological condition, and then thirty-four years later, also in a more or less similar pathological condition, but several thousand miles from the original place of discovery, is certainly worthy of note, though at the present time far from being explained. Unfortunately nothing is known concerning the mode of life, origin, or travels of the patient involved.

The refinding of *Eidamella spinosa* rejuvenates an old controversy concerning the possibility of sexuality among the ringworm fungi. It also reopens the old question of placement of these pathogenic organisms among lower Ascomycetes in the family Gymnoascaceae, instead of in the Fungi Imperfecti where they are now usually considered. Matruchot and Dassonville in their presentation of the belief that the dermatophytes belonged to this family of ascomycetes were rather dogmatic, and many workers including Sabouraud at that time considered that there was insufficient data then available for the final placement of these organisms here. Since then attempts have been made to do so,

although the state of knowledge today is much as it was in 1901 on this point.

Several reports of ascospore formation have appeared in the literature since that time. The report of the occurrence of asci in *Trichophyton Currii* by Chalmers and Marshall (1), with due regard for these workers, requires a comprehensive restudy of this organism and its coincidental comparison with various known sexual forms before it can be accepted.

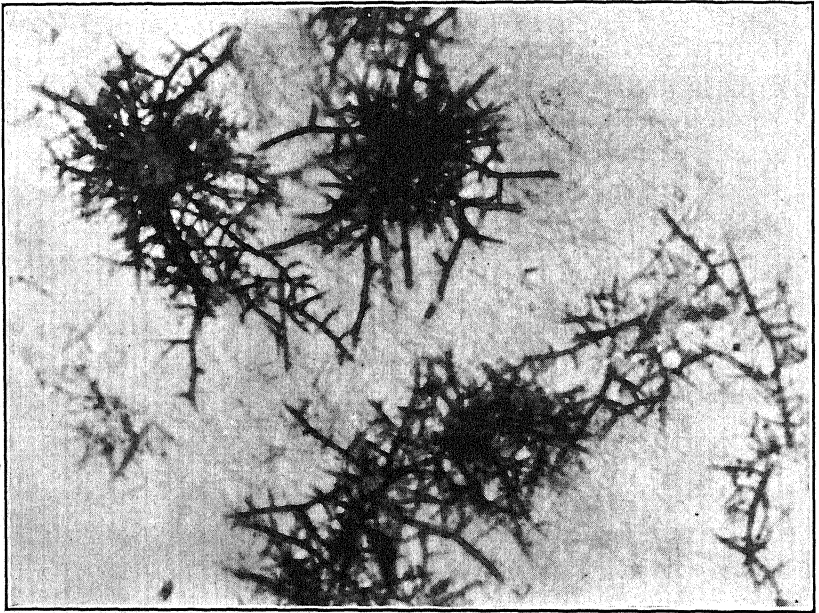


FIG. 27. Perithecia in *Eidamella spinosa*.

The brief report of *Gymnoascus gypseum*, published by Nannizzi (13) in 1927 in which he described asci has been severely criticised for lack of conclusive evidence. It is regrettable that Nannizzi did not produce a more comprehensive analysis with figures which could be used in comparison and identification.

If it is possible to obtain a culture of the organism described by Datta (4) for comparative purposes, it is hoped that an eventual understanding of the placement of this fungus, which seems at the moment to be the only acceptable case of a pathogenic fungus

producing perithecia yet reported, may be included in the final treatise of the family to be presented at a later time.

It is impossible to claim at the present that the refinding of *Eidamella spinosa* is conclusive evidence to the further establishment of the ringworm fungi as members of the family Gymnoascaceae, despite its cultural similarities and the similarities of the early sexual stages to nodular organs, etc. It is merely another link in a chain of evidence. The writer can find as yet no justification for the reclassification of the dermatophytes among the Gymnoascaceae, as done by Langeron and Milochévitch, Nannizzi, and others, even though the authors can cite morphological similarities between such forms as *Ctenomyces serratus* and certain of the true dermatophytes. Such a step must eventually be based upon the actual finding or inducement of bonafide sexual stages in an unquestionable pathogen; it must also bear repetition. The present case is the only one to date which can claim this last point of eminence, and to the mind of the present writer even this does not make it a sufficiently clear-cut case upon which to base a modified taxonomy.

From the purely mycological point of view it would be both interesting and valuable to know whether the ringworm fungi are members of the Gymnoascaceae. It would, however, of necessity be of purely theoretical interest and of very little practical value unless perithecia could be easily induced in all or most of the dermatophytes met with clinically; which is very unlikely. The practical handling and identification of these would still be as difficult as before.

As a matter of fact from the point of view of an individual attempting to learn something of the vagaries of these fungi, the classification presented by Sabouraud in 1910 has been neither added to nor elucidated, either by the attempts to place them in the Gymnoascaceae or by the numerous attempts to reclassify them by means of very variable botanical characteristics.

It is readily seen that until some more constant, easily recognizable, and usable criteria are found for the taxonomic diagnosis of these fungi, the present studies based on morphology, interesting as they are, add little to the clarification of this problem, though upon close analysis they may give some notion as to the limits of

variation of individual species, whatever species may eventually turn out to be.

With this in mind the refinding of *Eidamella spinosa* (Matruchot and Dassonville), found for the second time in 34 years in a pathological condition, but itself of questionable pathogenicity, is presented for whatever value and interest it may have from the point of view of those with a purely mycological interest.

To Professor J. G. Hopkins, Dr. R. W. Benham and Dr. B. O. Dodge I wish to express thanks for their interest and helpful suggestions. To Dr. N. F. Conant I wish to express my gratitude for turning over the cultures of *Eidamella spinosa* to me and thus making this and future studies on this form possible.

BIBLIOGRAPHY

1. Chalmers, A. J. & Marshal, A. 1914. The systematic position of the genus *Trichophyton* Malsten 1845. Jour. Trop. Med. (Hyg.) 17: 289.
2. —. 1914. *Tinea capitis tropicalis* in the Anglo-Egyptian Sudan. Jour. Trop. Med. & Hyg. 17: 257.
3. Dale, E. 1903. Observations on the Gymnoascaceae. Ann. Bot. 17: 571.
4. Datta, S. 1932. A new fungus, *Eidamella actoni*, parasitic to the dog. Indian Vet. Jour. 8: (Cited from Gregory.)
5. DeLamater, E. D. 1937. Crozier formation in the Gymnoascaceae. Mycologia 29:
6. Dodge, C. W. 1935. Medical Mycology, p. 900. Mosby Co. St. Louis.
7. Eidam, E. 1883. Jahresbericht der Schlesischen gesell. 175.
8. —. 1882. Botanische Centralblatt 10: 107.
9. Emmons, C. W. 1935. The ascocarps in species of *Penicillium*. Mycologia 27: 128.
10. Gregory, P. H. 1935. The Dermatophytes. Biol. Rev. Cambridge Phil. Soc. 10: 2.
11. Matruchot, L. & Dassonville, C. 1901. *Eidamella spinosa*, Dermatophyte produisant des Peritheces. Bull. Soc. Myc. Fr. 17: 123.
12. —. 1889. Sur le *Ctenomyces serratus*, Eidam compare aux champignons des teignes. Ibid. 15: 305.
13. Nanizzi, A. 1927. Ricerche sull'origin saprofitica dei funghi delle tigne. II. *Gymnoascus gypseus* (n. sp.), *Sabouraudites (Achorion) gypseum* (Bodin) Ota et Langeron. Inst. Bot. Roy. Univ. Siena.
14. —. 1926. Ricerche sui rapporti morfologici e biologici tra Gymnoascaceae de Dermatomiceti. Ibid. and Ann. Myc. 24: 85.

EXPLANATION OF FIGURES

All drawings were done with the aid of a camera lucida, $\times 1100$.

Fig. 1. Very young sexual coil arising from parent hypha. The uninucleate origin of the future nuclei of the coil is apparent.

Fig. 2. Slightly older stage showing the sterile, uninucleate central cell and a young coil, both arising from the same hypha.

Fig. 3. Slightly older coil (*a*) arising from same hypha from which a primordial protective (*b*) or peridial hypha is arising. The nucleus in the parent hypha has not yet divided, thus giving rise to the nuclei of each type of branch.

Fig. 4. (*a*) Young coil showing uninucleate condition before the basal wall has been formed. The sterile central cell arises from the opposite side of the same parent hypha. (*b*) Protective hypha which has arisen from the same parent hypha (out of the field) and which has become associated with the sexual structures.

Fig. 5. Somewhat older coil in the uninucleate condition before the basal wall has come in. A polar view of the nucleus in metaphase is shown enlarged to one side.

Fig. 6. Shows the 3-nucleate stage of the coil. The basal wall has been cut off. A sterile central cell is seen to arise from the parent hypha at the base of the coil.

Fig. 7. Older sexual coil showing segmentation into uninucleate cells. No central cell is evident.

Fig. 8. Older, more complex sexual coil wrapping about both the parent hypha and the sterile uninucleate central cell. No fusion between the coil and the central cell can here be seen. A sterile protective hypha is arising from the base of the coil; another is arising from the parent hypha.

Fig. 9. Very complex coil. The sterile central cell lies more or less in the center of this maze, unfused with any part of it.

Fig. 10. Somewhat later stage in which the sterile, unfused central cell; the coil; and protective branches arise from the same parent hypha or complex. Note that the peridial branches very soon after their appearance assume a very characteristic form which is easily recognizable.

Fig. 11. Coil and central cell arise from same parent hypha. No fusion between the central cell and the coil is evident. Note the enlarged size of the uninucleate cells of the coil.

Fig. 12. Very important stage. The origin of the binucleate condition of the cells of the coil which give rise to the croziers is indicated by the mitoses shown in the coil. The actual formation of binucleate crozier fundiments is seen. The sterile central cell which has arisen from a separate source from that of the coil is seen to be uninucleate and unfused with any part of the coil. The mitotic figures are numerous, and the indications are that there are five chromosomes. It is extremely difficult to be sure of an accurate count because of the very small size of the nuclei.

Fig. 13. Shows a very complex coil. It is seen here that the tip of the coil seems to fuse with the central cell. Due to the complexity of the structure it was very difficult to determine this with certainty. It is presented as a possible case of fusion only. It has been observed also by Dr. Rhoda Benham and others and was considered as questionable by them also.

Fig. 14. Sexual coil showing croziers arising from it. Nuclei are migrating to appropriate position for conjugate division in crozier and are in what appears to be early prophase.

Figs. 15, 16, 17, 18, and 19 are various stages in the development of the croziers. The lower hook process in No. 15 shows essentially what is seen in Fig. 14. Figure 17 shows the fusion of the tip cell of the crozier with the basal cell in the reestablishment of the binucleate condition. The young ascus is seen to be binucleate at this stage. Figure 19 shows the young ascus formed directly after the conjugate division. Here the fusion of the tip cell with the basal cell of the crozier has not yet occurred. Figure 18 shows a young ascus arising from a crozier which arose directly from the coil. It is seen that nuclei in this young ascus are in the process of fusing, thus establishing the diploid nucleus of the ascus, which is later reduced at spore formation. Such a meiosis is here postulated, but has not as yet been observed in *Eidamella spinosa*.

Fig. 20 and 21. Other stages in crozier formation.

Fig. 22. Shows the young ascus elongating, thus approaching its mature shape.

Fig. 23. Shows three fully mature asci with their included ascospores. Eight ascospores are usual per ascus, in fact no other number has ever been observed. Note also the dipodial bases of the asci, indicating their crozier origin. A young crozier and an ascus in which no spores have yet been cut out are shown.

Fig. 24. Mitotic figures observed in developing peridial hyphae. Prophase, metaphase, and telophase are shown. Such figures as these also indicate a probable haploid chromosome number 5, possibly 4, 6, or 7. They are much too small to be made out with certainty.

Fig. 25. Typical spirals which occur at the tips of peridial branches closely surrounding the cluster of asci in the center of the loose, arachnoid perithecium. Note the blackish, thick-walled cells from which they arise.

Fig. 26. Young sexual coil with dark, thick-walled peridial hyphae being differentiated around it from the surrounding aerial hyphae, which, other than their proximity have no direct connection with the sexual coil itself.

Thanks are tendered to Mr. Alfred Feinberg for his helpful suggestions in the execution of these drawings; and to Dr. Rhoda Benham for her thoughtful observation of many of the structures here drawn.

Fig. 27. Photomicrograph of perithecia in cornmeal agar culture of *Eidamella spinosa* (low power).

MISCELLANEOUS NOTES ON THE USTILAGINALES¹

GEORGE L. ZUNDEL

(WITH 1 FIGURE)

This paper is a record of miscellaneous observations on the Ustilaginales as follows,

I

Thecaphora leptideum (Syd.) Zundel, comb. nov.

Tolyposporium leptideum Syd. Ann. Myc. 11: 365. 1913.

In 1913 Sydow described a smut on *Chenopodium album* L. collected at Forbach, Lorraine, France to which he gave the name of *Tolyposporium leptideum* and published the following description:

"Soridis in ovariis leniter quam normales majoribus evolutis, matricem leniter deformantibus, cinnamomeo-brunneis; glomerulis rotundatis 35–50 μ diam., vel rarius ellepticis aut oblongis et tunc usque 60 μ longis, ex sporis numerosis denissime coalitis compositis; sporis singulis angulato-globosis, angulato-ovatis vel cuneatis, superficie verruculosis, ad latera levibus, dilute brunneis, 9–16, 8–12 μ , membrana ca. 1 μ crassa."

Besides the type specimen, material collected near Kreuzeburg, Germany, Hungary, and Brno, Czechoslovakia, has been examined. It was noted that the spore balls are yellowish in color. According to the usually accepted classification, all smuts with yellowish or reddish colored spore balls are referred to the genus *Thecaphora*. The spore balls of the genus *Tolyposporium* are always dark colored. The name of this smut then should be *Thecaphora leptideum* (Syd.) Zundel.

In a collection of unnamed specimens of smuts I found one that had been sent to me from New South Wales and labeled "*Soro-*

¹ Contributions from the Department of Botany, The Pennsylvania State College, No. 99.

sporum sp. on *Chenopodium ambrosioides* L., Coll. 1914, N.S.W." The name of the collector is not given. An examination of this specimen revealed that it was *Thecaphora leptideum*. This is apparently the first report of this smut from Australia and also the first report outside of Central Europe.

SOROSPORIUM CONSANGUINEUM Ellis & Ev. Jour. Myc. 3: 56. 1887.

Ustilago Aristidae Peck, Bull. Torrey Bot. Club 12: 35. 1885.

Sorosporium Bornmülleri P. Magn. Ver. Zool.-Bot. Gesell. (Wien) 50: 434. 1900. (Not *S. Aristidae* Neger, Anal. Univ. Santiago (Chile) 93: 789. 1896.)

In 1885 Peck described a smut on "*Aristida Rusbyi*" (*A. arizonica*) to which he gave the name *Ustilago Aristidae*. Later it was found that this smut was a *Sorosporium* and in 1887 Ellis and Everhart renamed the smut *Sorosporium consanguineum*. In 1900 P. Magnus described a *Sorosporium* on *Aristida coerulescens* Desf. from Syria which he named *Sorosporium Bornmülleri*. The Magnus species was later collected in 1931 by P. Unamuno in Morocco on *Aristida coerulescens* Desf. A comparison of the specimen of *S. Bornmülleri* collected in Morocco and specimens of *S. consanguineum* collected in different parts of the world reveals that both species are identical. The name *S. Bornmülleri* must therefore be relegated to synonymy.

II

The following smuts were collected by Dr. A. S. Hitchcock in 1929 during a trip to Africa to collect grasses. Most of the hosts are apparently new for the smut species.

1. *USTILAGO CYNODONTIS* P. Henn. On *Cynodon plectostachyum* (K. Schum.) Pilger, Kampala to Jinja, Uganda, Sept. 18, 1929, No. 24951.

2. *USTILAGO DIGITARIAE* (Kunze) Winter. On *Digitaria abyssinica* (Hoch) Stapf, Kisumu, Kenya, Sept. 15, 1929, No. 24844; on *Digitaria* sp., Entebbe, Uganda, Sept. 16, 1929, No. 24877.

3. *USTILAGO RABENHORSTIANA* Kühn. On *Digitaria horizontalis* Willd., Nairobi to Nanyuki, Kenya, Sept. 1929, No. 24764.

4. *Ustilago Hitchcockiana* Zundel, sp. nov.

Sori entirely destroying and deforming the inflorescence, linear, usually 2–7 cm. long, at first concealed by the glumes, covered with a brown membrane which flakes away revealing a dark brown spore mass; spores globose—subglobose, light olivaceous, $3.5\text{--}5.5\ \mu$ diam., rarely $7\ \mu$, smooth, guttulate.

Soris linearibus, saepissime 2–7 cm. longis, inflorescentiam ex toto destruantibus, et deformantibus, primo in glumis inclusis, membrana brunnea tectis, eaque rupta pulverem sporarum fuscam ostensis; sporis globosis vel subglobosis, pallide olivaceis, $3.5\text{--}5.5\ \mu$ raro $7\ \mu$ diam., levibus guttulatis.

On *Cynodon Dactylon* (L.) Pers., Nairobi, Kenya, Sept. 26, 1929. A. S. Hitchcock No. 25142.

Three species of smuts have been previously reported on species of *Cynodon* as follows:

1. *USTILAGO DREGEANA* Tul. Ann. Sci. Nat. III. 7: 83. 1847.

Type host and locality: On a grass. Cape of Good Hope, Africa.

This species has globose-subglobose spores, olivaceous brown, $4\text{--}5\ \mu$ diam., indistinctly and sparsely papillate.

2. *USTILAGO CYNODONTIS* P. Henn. Bot. Jahrb. (Engler) 14: 369. 1891.

Type host and locality: On *Cynodon Dactylon* (L.) Pers., Abyssinia, Africa.

This species has globose-subglobose (or occasionally ellipsoidal) spores, olivaceous, $7\text{--}10\ \mu$ diam., smooth, granular (some writers describe this species as almost smooth).

3. *USTILAGO PARAGUARIENSIS* Speg. Anal. Soc. Cien, Argentina 17: 89. 1884.

Type host and locality: On *Cynodon dactylon*, Paraguay.

This species is described as having globose spores, dark olivaceous, $7\text{--}9\ \mu$ diam., granular papillulate.

None of the described species have spores identical to *Ustilago Hitchcockiana*. *Ustilago Dregeana* Tul. has spores about the same size as *Ustilago Hitchcockiana* but differs in having a papillate epispore. The writer has not been able to locate an authentic specimen of *Ustilago Dregeana* Tul.

5. *Sphacelotheca Kenyae* Zundel, sp. nov.

Sori destroying the inflorescence, about 1 cm. long, concealed by the glumes, covered by a delicate brown membrane which flakes away revealing a semi-agglutinated mass of spores surrounding a columella; sterile cells globose-ellipsoidal, usually regular, hyaline, 12-17 μ diam., usually in pairs; spores globose-subglobose, olivaceous with a thick epispore, usually 9-11 μ diam., smooth non-granular.

Soris circa 1 cm. longis, inflorescentiam destruantibus, in glumis inclusis, membrana tenue brunnea tectis, eaque rupta pulverem sporarum semi-agglutinatarum columellam amplectentium ostensis; cellulis sterilibus globose-ellipsoideis, saepissime geminatis; sporis globosis vel subglobosis, olivaceis, saepissime 9-11 μ diam., nongranularibus, episporio crasso, levi.

On *Hyparrhenia* sp. Eldoret, Kenya, Sept. 20, 1929, Coll. A. S. Hitchcock, No. 25028.

This species is closely related to *Sphacelotheca Ruprechtii* Syd. The size and color of the spores of the two species is identical. *Sphacelotheca Ruprechtii* differs from *Sphacelotheca Kenyae* by having smooth granular spores, smaller sterile cells and a larger sorus.

6. *TILLETIA HETEROSPORA* (P. Henn.) Zundel (*Ustilago heterospora* P. Henn.; *Tilletia Ayresii* Berk.).

On *Setaria aurea* Hochst., Jinja, Uganda, Sept. 18, 1929. No. 24962.

III

Through the kindness of Dr. W. Robyns, Director of the Jardin Botanique de l'Etat, Bruxelles, Belgium, eleven specimens of smuts collected in the Belgian Congo by Hyac. Vanderyst, missionary, were loaned for study. Most of them are type specimens used by P. Hennings for the original descriptions. On the sheets are the original notations and pencil drawings made by P. Hennings. In general, the specimens contain few spores and fewer sori. The result of examining the specimens is as follows:

USTILAGO BECKERAE P. Henn. Ann. Mus. Congo V. 2: 86. 1907.

An examination of the type specimen fails to show the presence of any smut spores although P. Hennings has pencil drawings of apparently typical *Ustilago* spores attached to the sheet. Appar-

ently the supply of smut spores was very limited and all of them have been used in study. Since this smut has been collected only once, it seems best to regard *Ustilago Beckerae* as a doubtful smut until more material is collected. One spikelet resembling a sorus of a *Ustilago* is in a small packet in the upper left hand corner of the sheet but an examination under the microscope showed it to be a dark spored species of the Fungi Imperfecti. This material is also the type for *Plascosphaeria Beckerae* P. Henn.

On *Beckera* sp., Kisantu, Congo, May 1906, Coll. Vanderyst, No. 169.

USTILAGO SETARIAE-AUREAE P. Henn. Ann. Mus. Congo V. 2: 86. 1907.

An examination of the type specimen shows that the original description can be rewritten as follows:

Sori destroying the ovaries, inflated; spores subglobose, irregular, olivaceous brown, 3.5–5 μ diam., verruculate to tuberculate.

On *Setaria aurea* Hochst., Dembo, Congo, June 1906, Coll. Vanderyst, No. B28.

USTILAGO ISCHAEMOIDES P. Henn. Ann. Mus. Congo V. 2: 86. 1907.

An examination of the type specimen reveals the presence of spore balls. This character places the species in the genus *Sorosporium*. A redescription is as follows:

Sorosporium ischaemoides (P. Henn.) Zundel, comb. nov.

Sori destroying the inflorescence, horn shaped, about 1 cm. long, covered by a thick yellowish colored membrane which dehisces apically revealing a granular spore mass surrounding a simple columella; spore balls opaque, many spored, subglobose-ellipsoidal, irregular, semi-permanent, reddish brown, 50–105 μ long; spores subglobose-ellipsoidal, dark olivaceous brown (spores on the interior of spore balls, lighter colored), thick episporous, about 2 μ thick, 7–10 μ diam., smooth.

On *Andropogon* sp., Leopoldville, Congo, May 1906, H. Vanderyst, No. 121.

Attached to the specimen is the original description apparently in the handwriting of P. Hennings.

CINTRACTIA CONGENSIS P. Henn. Ann. Mus. Congo V. 2: 87. 1907.

Sori in the axiles of the stem whorls and extending up on the side branches, agglutinated, at first covered with a delicate membrane; spores globose-ellipsoidal, regular, dark olivaceous brown, 7–10 μ diam., smooth and somewhat granular.

On an unidentified species of the Cyperaceae, at the side of a path between Matada and Leopoldville, Congo, May 19, 1906, Coll. H. Vanderyst, No. 105. This is the type specimen.

The original description describes the spores as angular. An examination of the type specimen did not show this character and furthermore the original drawings by P. Hennings do not show angular spores.

CINTRACTIA TOGENSIS P. Henn. Bot. Jahrb. (Engler) 38: 119. 1905–1907.

Sori destroying the inflorescence, ellipsoidal, hard crusted but spores wear off producing a powdery mass, about 1 cm. or less; spores globose—broadly ellipsoidal, regular, occasionally with hyaline wings, light olivaceous brown, not opaque, 10–14 μ diam., smooth.

On an undetermined species of the Cyperaceae, Kisantu, Congo, May 1906, Coll. H. Vanderyst, No. 126.

The specimen examined is not the type but it was determined by P. Hennings.

CINTRACTIA VANDERYSTII (P. Henn.) Zundel, Mycologia 22: 128. 1930.

Ustilago Vanderystii P. Henn. Ann. Mus. Congo V. 2: 86. 1907.

Sori destroying the basal parts of inflorescence, long linear, 5–10 mm. long, concealed by the glumes, at first covered by a tawny colored membrane; spore masses agglutinated around a central columella; spores subglobose-ellipsoidal, fragile, olivaceous brown, 7–10 μ diam., smooth but granular.

On *Andropogon* sp., Kisantu, Congo, Coll. H. Vanderyst, 1908.

The specimens examined were determined by P. Hennings but were not type specimens.

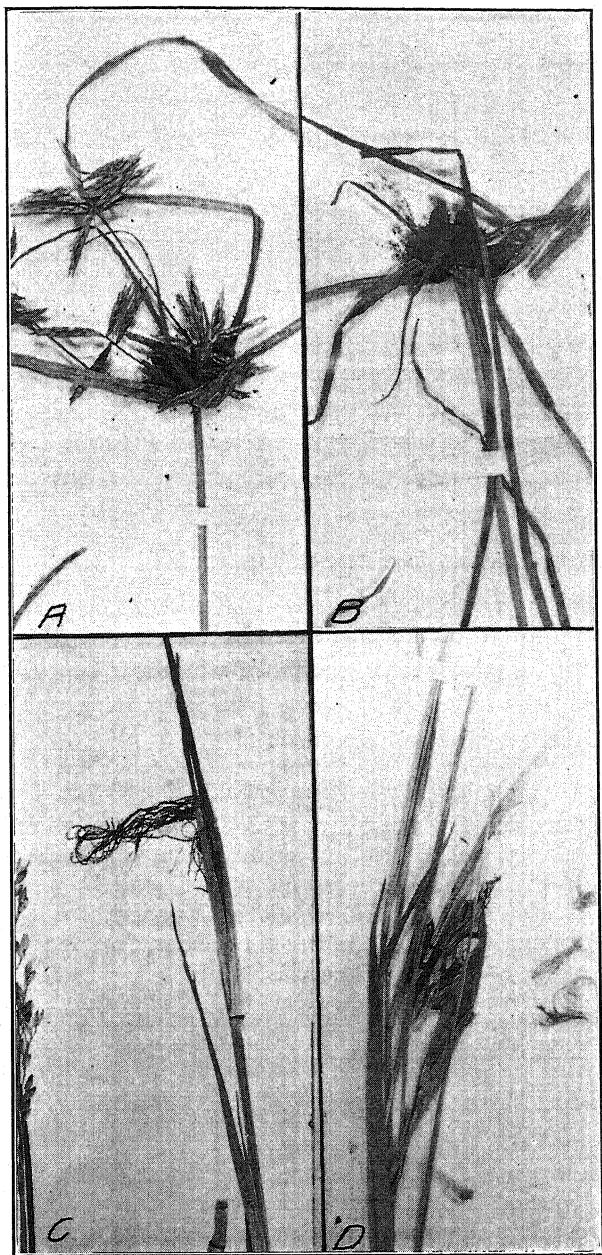


FIG. 1. A, *Cintractia congensis* P. Henn.; B, *Cintractia togensis* P. Henn.; C, *Sorosporium kinshaensis* (Beeli) Zundel; D, *Sorosporium Wildemani-
anum* P. Henn.

SOROSPORIUM PANICI Beeli, Bull. Jard. Bot. Brux. 8: 7. 1923.

An examination of the type specimen reveals the presence of two fungi neither of them a *Sorosporium*. One of them was found to be a *Cladosporium*-like fungus, the other is a *Ustilago*, near or identical to *Ustilago ugandensis* P. Henn. In the absence of authentic material of *U. ugandensis*, this determination is not final. The drawings intended for *Sorosporium* spore balls are not typical for this genus.

Even if this was a *Sorosporium* the specific name "*Panici*" could not be used here since in 1912 MacKinnon used the binomial *Sorosporium Panici* for another smut found in Australia. Previous to having this specimen available for examination the author had changed the name of the Beeli material to *Sorosporium Beelii* in a paper now gone to press.

SOROSPORIUM PANICI var. KINSHASAENSIS Beeli, Bull. Jard. Bot. Brux. 8: 8. 1923.

An examination of the type specimen shows that this smut is not related in any way to the species of which it is supposed to be a variety. It is therefore proposed to raise the variety to specific rank with the following description:

Sorosporium kinshasaensis (Beeli) Zundel nom. nov.

Sori destroying the inflorescence, 3–5 mm. long, at first concealed by the glumes, covered by a membrane which flakes away revealing a granular spore mass intermixed with brown shreds; spore balls usually ellipsoidal, somewhat irregular, opaque, many spored, permanent; spores globose-subglobose, irregular, reddish brown, fragile, 5–8 μ diam., smooth.

On *Panicum kinshasaense* Vanderyst, Kinshasa, Congo, June 2, 1916, Coll. H. Vanderyst, No. 4.

SOROSPORIUM WILDEMANIANUM P. Henn. Ann. Mus. Congo V. 2: 87. 1907.

Sori destroying the inflorescence, long linear, 1–1.5 cm. long, grouped, covered with a thick smooth membrane which ruptures apically revealing a granular spore mass intermixed with long dark shreds; spores subglobose-ellipsoidal, somewhat angular, not fragile, olivaceous with a thick reddish brown epispore about 1.5 μ thick, 7–11 μ diam., verruculose on exposed surface, otherwise smooth.

On *Andropogon Gayanus* Kunth., Dembo, Congo, June 3, 1908, Coll. H. Vanderyst.

In the specimen examined the spore balls had entirely disintegrated. The original description describes them as "glomerulis ellipsoideis vel subglobosis e sporis numerosis compositis, $50-80 \times 50-60 \mu$."

The author in 1930 (*Mycologia* 22: 146. 1930) published a description of this species which states that the sori were on the leaves. Evidently the material used has not been correctly named although it was marked *S. Wildemanianum* and was sent as a correct determination. The specimen examined for the present paper has been previously determined by P. Hennings and is considered correct.

PENNSYLVANIA STATE COLLEGE,
STATE COLLEGE, PENNSYLVANIA

EXPLANATION OF FIGURE

Congo smuts collected by H. Vanderyst and deposited in the Herbaier du Botanique de l'Etat, Bruxelles.

A. Cintractia congensis P. Henn.

Herbier de Hyac. Vanderyst, No. 105. Photo of type specimen.

B. Cintractia togensis P. Henn.

Herbier de Hyac. Vanderyst, No. 126. Photo not type specimen but determined by P. Hennings.

C. Sorosporium kinshaensis (Beeli) Zundel.

Herbier du Jardin Botanique de l'Etat, Bruxelles, Leg. H. Vanderyst.
Photo of type specimen.

D. Sorosporium Wildemanianum P. Henn.

Herbier du Jardin de Botanique de l'Etat, Bruxelles, Coll. H. Vanderyst, 1908. Photo not type specimen but determined by P. Hennings.

NOTES ON THE GENUS MICROMYCES

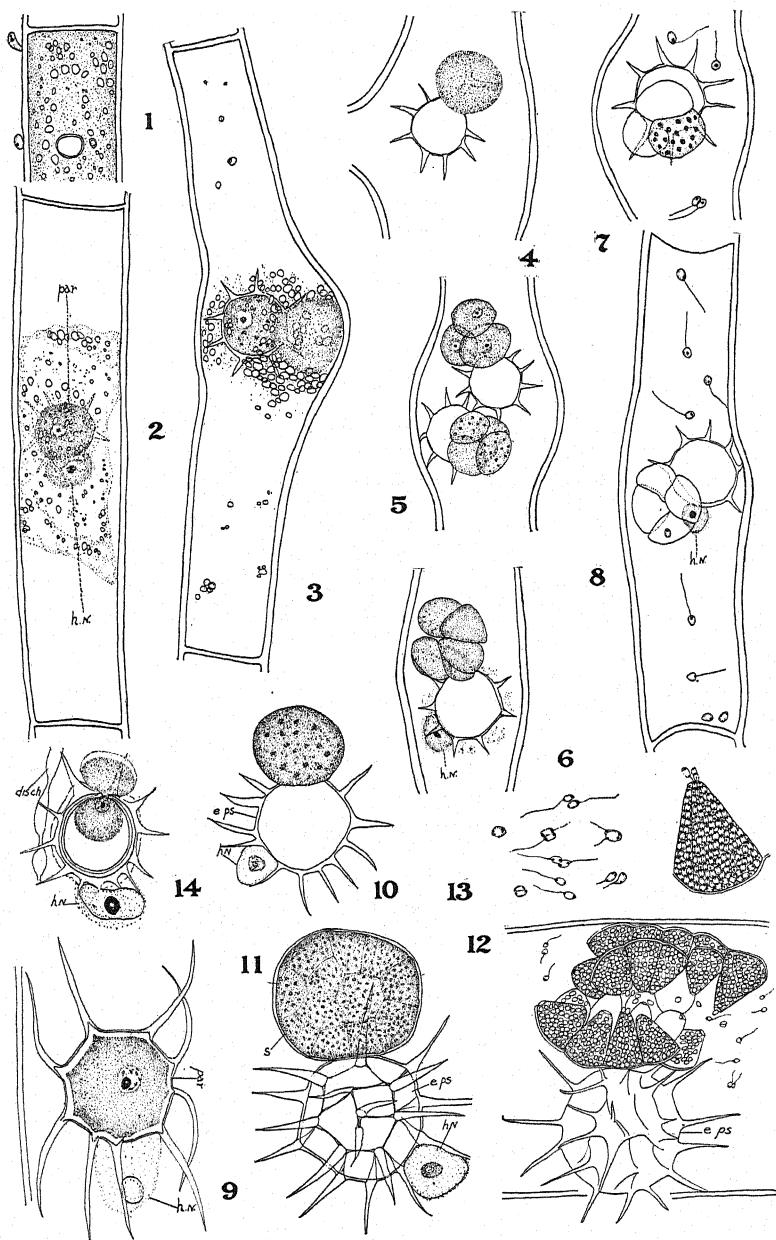
JOHN N. COUCH

(WITH 14 FIGURES)

In 1931 the writer described the life history of a species of *Micromyces* from Long Island, N. Y., which he at that time thought was *M. Zygonii* Dangeard. Although there were certain distinct differences between the American fungus and the European, it seemed best at the time to consider the two as the same. Since then, however, we have twice collected at Chapel Hill, N. C., in large quantity, a fungus which agrees in all respects with the European *M. Zygonii* Dangeard as understood by Heidt (1937) in his recent detailed treatment of this species. Fortunately three excellent slides of the Long Island parasite have been preserved and hence could be compared first hand with the Chapel Hill fungus. Such comparison has shown beyond doubt that the two are very distinct from each other. The Long Island plant is also quite distinct from *M. Spirogyrae* Skvortzow (1927) and *M. Petersenii* Scherffel (1926). It is therefore necessary to give the Long Island plant a new name and since it has by far the longest spines of any of the species of the genus the name *longispinosus* would seem appropriate. Since a rather complete account of this form was given by the writer (1931) including the fusion of planogametes, only a short description will be repeated here.

***Micromyces longispinosus* sp. nov.** (*Micromyces Zygonii* Dang. sense of Couch, 1931, but not Dangeard or Heidt, 1937).

Thallus at first a naked, amoeboid, plasma body within the algal cell. At length coming to rest next to the nucleus of the host and growing at the expense of the latter; forming at maturity a more or less spherical body, the prosorus, which contains a single large nucleus up to $8\ \mu$ thick. Prosori $10\text{--}33.6\ \mu$ thick, most about $21\ \mu$ thick. Covered by a hyaline, spiny membrane or rarely the membrane may be nearly smooth. Spines up to $22\ \mu$ long, most about $12\ \mu$ long. The number of spines varies from about 12–24.



FIGS. 1-8. *Micromyces Zygogonii*.
 FIGS. 9-14. *Micromyces longispinosus*.

Membrane irregularly reticulated between the spines. The prosorus may germinate directly, discharging its contents into a vesicle, the contents of which now cleave into from about 8 to 24 or even more sporangia. Sorus globose or ovoid, remaining attached to the empty prosorus until after the sporangia are formed, and then losing its shape more or less completely by the swelling and bursting apart of the sporangia. Sporangia usually polygonal in shape, about $8.4 \times 9.6 \mu$ thick in their two greatest dimensions; sometimes pyramidal in shape, but with a rounded base and a truncated apex. The contents of the sporangia quickly divide into many, very small, uniciliate zoöspores. Zoöspores subglobose or ovoid with a glistening droplet at one or both ends, about 1μ thick. Planogametes (?) also formed which apparently fuse to form zygotes. The thallus may become transformed into a pale yellowish brown and thick-walled, uninucleate resting body, which is covered with a hyaline spiny membrane; resting bodies $16-21 \mu$ thick, discharging their contents into a vesicle. The contents later perhaps cleave to form sporangia.

Thallus intra cellulas *Spirogyrae* parasiticus, primo nudus. Prosori 12-24 numero, $10-33.6 \mu$ diam., plerique 21μ , membrana aculeata, spinis ad 22μ longis, plerisque 12μ longis. Prosorus sorum generans, qui in 8-24 vel plura sporangia dividitur. Sporangia $8.4 \times 9.6 \mu$. Zoosporae admodum parvae, fere 1μ diam., uniciliatae. Sexuales cellulae etiam formatae. Sporangia perdurantia $16-21 \mu$.

Found in the cells of *Spirogyra* sp. in a small pond near Cold Spring Harbor, L. I., N. Y., August 7, 1925. The species of *Spirogyra* appears to be near *S. adnata*, but since the alga was only in the vegetative condition, I could not be sure of its identity. The cells measured $37-44 \times 147-190 \mu$; without replicate ends. Chlorophyll bands 3 or 4 making about 2 complete turns. In the same material there was another species of *Spirogyra*, slightly smaller and with only one chlorophyll band. This species was entirely untouched by the parasite.

The present species is very distinct from *M. Zygonii* Dangeard as indicated in the tabulated comparison below.

| MICROMYCES LONGISPINOSUS | M. ZYGONII Dangeard |
|---------------------------------------------------|--------------------------------------------|
| Prosori 10-33.6, most about 21μ thick | Prosori 11-16.8, most about 13μ thick |
| Spines 10-22 μ long, most about 12μ long | Spines 4-5.5 μ long |
| Sporangia 8-24 in each sorus | Sporangia 4-6 in each sorus |
| Spores about 1μ thick | Spores about 2μ thick |
| Resting bodies 16-21 μ thick | Resting bodies about 12μ thick |

MICROMYCES ZYGOGONIÏ Dangeard.

Thallus parasitic in the cells of *Mougoetia*, *Zygogonium*, and other Zygnemales. At first amoeboid, usually coming to rest within the host cell near the nucleus. Sometimes the parasite may develop not in contact with host nucleus. Forming at maturity a spherical, spiny body, the prosorus. During the development of the prosorus the host cell usually swells considerably, sometimes to twice its normal diameter, sometimes even bursting as a result of the internal pressure, and the protoplast becoming more or less disorganized. Usually one prosorus to a host cell but sometimes several may be formed. Prosorus 11–16.8 μ thick, with 14–18 sharply pointed hyaline spines which are 4–6 μ long. Mature prosorus with a single large nucleus. At maturity the prosorus germinates, emptying its entire contents in a spherical mass which becomes cut up into 4–6 sporangia. Sorus spherical at first, irregular in outline after the sporangia have been formed, 13–18 μ thick. Sporangia irregular in shape, the inner walls are flattened by pressure while the outer wall is rounded. Spores rounded or ovoid, with one posteriorly directed cilium and one shiny body in the protoplast, slightly more than 2 μ thick. Spores discharged within a host cell on April 27 were still capable of motion the following day. Spores swimming as typical for uniciliate chytrid spores. Resting bodies spherical with less conspicuous spines than on the sporangia, about 12.5 μ thick, with a thick brownish inner wall. The resting bodies seem to cause no distortion in the threads.

Collected twice at Chapel Hill, N. C. In *Zygogonium* sp. Jan. 1933. J. N. Couch, coll. In *Mougoetia* sp. April 1933. Willard Hewitt, coll. This species is widespread in Europe, having been first described by Dangeard (1889, 1890–91) in France, in *Zygogonium*; by Petersen (1910) in North Sealand and Jutland, in *Mougoetia* sp.; by Denis (1926) in the high Pyrenees, elevation 2000 m., France, in *Spirogyra quadrata*; by Huber-Pestalozzi (1931) in Switzerland, in *Mougoetia* sp.; and by Heidt (1937) in Germany, in *Mougoetia scalaris* Hass.

UNIVERSITY OF NORTH CAROLINA,
CHAPEL HILL, N. C.

LITERATURE CITED

- Couch, John N. *Micromyces Zygogoniï* Dang., parasitic on *Spirogyra*. Jour. Elisha Mitchell Sci. Soc. 46: 231–238. pl. 16–18. 1931.
Dangeard, P. A. Memoire sur les chytridiées. Le Botaniste 1: 52–56. pl. 2, fig. 1–10. 1888.

- . Maladies des Algues et des Animaux. Le Botaniste 2: 245-246. pl. 17, fig. 3-8. 1891.
- Denis, M. La Castration des Spirogyres par des Champignons parasites. Revue Algologique 3: 14-21. fig. 2. 1926.
- Heidt, Karl. Beitrag zur Kenntnis der Gattung micromyces. Ber. Deuts. Bot. Ges. 55: 204-217. fig. 1-8. 1937.
- Huber-Pestalozzi, G. Infektion einer *Mougoetia*—Population durch *Micromyces zygogonii* Dang. an einem alpinen Standort. Hedwigia 71: 88. 1931.
- Petersen, H. E. An account of Danish Freshwater Phycomycetes. Ann. Myc. 8: 556. fig. 27c. 1910.
- Scherffel, A. Einiges über neue oder ungenügend bekannte Chytridinen. Archiv Protistenkunde 54: 167-260. pl. 9-11. 1926.

EXPLANATION OF FIGURE

All figures except 13 drawn under Leitz 1.4 n. A. oil imm objective and 8 ocular, giving a magnification of 1250. Fig. 13. 2400. All figures reduced one-half in reproduction.

Fig. 1-8. *Micromyces Zygogonii* Dangeard. 1, zoöspores on *Mougoetia* thread, ready to penetrate. 2, host cell containing parasite (par). Host protoplast shows considerable collapse; host nucleus (h.n.) is in contact with parasite. Nucleus of parasite is distinct, as are also the young spines. 3, mature prosorus with distinct nucleus and spines. Host cell is swollen and bent and of the host protoplast there remains only a disorganized mass of greenish matter and numerous granules perhaps starch. 4, host cell has burst. Prosorus has discharged to form sorus, the contents of which have begun to cleave into sporangia. 5, empty prosori with sori, each composed of four sporangia. 6, empty prosorus with old host nucleus (h.n.) attached. Sorus has divided into four sporangia. 7, sorus with four sporangia three of which have discharged spores (sp.), two of which are apparently fusing. 8, sorus of four sporangia all of which have discharged spores (sp.). After 24 hours some of these spores were still capable of swimming. Note host nucleus (h.n.). 9-14. *Micromyces longispinosus*. These figures are taken from Couch (1931). Due to limitations of space, the host cell walls are shown only in fig. 12. 9, sorus showing long spines, host nucleus (h.n.) and parasite nucleus. 10, empty prosorus and sorus. Note granules, perhaps nuclei, in sorus. 11, sorus divided into sporangia. 12, sorus of sporangia broken up. Some sporangia are discharging spores, others are empty. Some of the spores are apparently fusing. 13, single sporangium discharging spores some of which are apparently fusing. 14, resting body in process of germination; note vesicle from which protoplasm has partly collapsed, dis. ch., disintegrated chloroplast; h.n., host nucleus.

THE OCCURRENCE OF A HUMAN PATHOGENIC FUNGUS AS A SAPROPHYTE IN NATURE

NORMAN F. CONANT

The feeling that many of the fungi pathogenic for man must occur as saprophytes or parasites in some unrecognized natural habitat has existed for several years. Attempts to link the skin fungi or dermatophytes with forms already known to occur in nature on substrates of horny material have, as yet, produced no complete evidence of identity. Likewise, several attempts to isolate skin fungi from shower bath floors, swimming pools, and other likely places of contamination have failed to produce forms known to be pathogenic for man.

One fungus, however, *Phialophora verrucosa* Thaxter in Medlar 1915, a form which has been isolated from cases of chromoblastomycosis in Boston, Texas, Uruguay, and other South American localities can now be definitely identified with fungi of the genus *Cadophora* which have been isolated from pulp wood and unfinished pine and spruce timbers in this country and Europe.

When Thaxter described the endogenous manner of conidial formation of *Phialophora verrucosa* in 1915, he suggested that "the fungus should be classed under the sub-division Chalareae of Saccardo's classification and should be the type species of a new genus." Likewise, Lagerberg and Melin when describing the conidial formation of *Cadophora fastigiata* in 1927 suggested that the fungus be placed in the Chalareae of the Dematiaceae. In 1934 five other species were added to the genus *Cadophora* by Melin and Nannfeldt, while in 1935 Davidson added two more.

A careful comparative study of the eight species of *Cadophora* described from lumber and pulp wood and three strains of *Phialophora verrucosa* isolated from cases of chromoblastomycosis has shown that these fungi belong to the same genus. While different species exist, the generic character of endogenous conidial

formation from ampullaceous conidiophores bearing funnel or cup-like structures at the apices, is common to all of the fungi. The genus *Cadophora* Lagerberg and Melin 1927 must, therefore, fall into synonymy with *Phialophora* Thaxter 1915. Therefore the following new synonymy and new combinations are made; thus, *Cadophora americana* Nannf. becomes a synonym of *Phialophora verrucosa* Thaxter, and the following species of *Cadophora* are transferred: ***Phialophora fastigiata*** (Lagerb. & Melin) Conant, ***Phialophora brunnescens*** (Davidson) Conant, ***Phialophora Lagerbergii*** (Melin & Nannf.) Conant, ***Phialophora Melinii*** (Nannf.) Conant, ***Phialophora obscura*** (Nannf.) Conant, ***Phialophora repens*** (Davidson) Conant, and ***Phialophora Richardsiae*** (Nannf.) Conant.

A full report of the work concerning these fungi will appear later.

DEPARTMENT OF BACTERIOLOGY AND MEDICINE,
DUKE HOSPITAL,
DURHAM, NORTH CAROLINA

LITERATURE CITED

1. Medlar, E. M. A new fungus, *Phialophora verrucosa*, pathogenic for man. *Mycologia* 7: 200-203. 1915.
2. Lagerberg, T., Lundberg, G. & Melin, E. Biological and practical researches into blueing in pine and spruce. *Svenska Skogsvards. Tidskr.* 25: 145-272. 1927.
3. Melin, E. & Nannfeldt, J. A. Researches into the blueing of ground wood-pulp. *Svenska Skogsvards. Tidskr.* 32: 397-585. 1934.
4. Davidson, R. W. Fungi causing stain in logs and lumber in the southern states including five new species. *Jour. Agr. Res.* 50: 789-807. 1935.

STUDIES OF CERTAIN SPECIES OF MELANCONIS ON CARPINUS, OSTRYA AND CORYLUS¹

LEWIS E. WEHMEYER

(WITH 3 FIGURES)

There occur, upon *Carpinus*, *Ostrya* and *Corylus*, a difficult group of related species of *Melanconis* which have been described under many names in a number of genera. Although this group of species, or varieties, shows a rather wide range of variation in certain characters, it is difficult to distinguish morphologic species because of the overlapping ranges of variation. The literature and exsiccati of these species are also extremely confusing. It is the purpose of this paper to present and review certain data which may help to clear up this situation.

PERITHECIAL STAGE

A study of a large number of collections and exsiccati of this group of species from various hosts, from both Europe and America, and both in the fresh and dried condition, shows that there is a great deal of variation in a number of characters. Superficially, they vary from minute pustules to rather widely erumpent discs. The ectostroma varies in size from 250–2000 μ or more in diameter and from a dull gray, through gray-green to yellow- or olive-green in color, and may be sharply outlined or merged with a slight entostromatic development in the bark. The spores, when young, are small fusoid with tapered ends which may bear faint pointed or globose evanescent appendages. With maturity, they become rounded at the ends and constricted at the septum. In dried material, the protoplast may shrink giving the appearance of a thickened wall. In size, the spores are from 11–27 by 3–9.5 μ . The asci vary from 50–127 \times 6.5–14 μ . In spite of these variations,

¹ Papers from the Department of Botany and the Herbarium of the University of Michigan, No. 621.

very little correlation could be found between the different characters or between these and the host.

In a previous study (14), this group was broken up into three species (*M. xanthostroma*, *M. hyperopta* and *M. sulphurea*). A tabulation by hosts, of spore measurements from some forty-one European and twenty-four American collections indicated that there were two rather than three species represented. One of these, *M. sulphurea*, on *Corylus*, has larger spores (18) $20-27 \times 6-9.5 \mu$, whereas the second, *M. xanthostroma*, on *Carpinus* and *Ostrya*, has somewhat smaller spores (10) $11.5-20$ (23) \times (3) $3.5-5$ (7) μ . The spores found on *Carpinus* and *Ostrya* show two general groups, one measuring $11-15 \times 3-5 \mu$ and the other $15-23 \times 5-6 \mu$, but there are many collections showing overlapping ranges as regards spore size. That this difference in spore size is due, in part at least, to the maturity of the spore and the vigor of development, is supported by the fact that one collection on *Carpinus* (Wehm. Herb. No. 3625) which had spores measuring $11.5-15 \times 3-4 \mu$ when collected, yielded spores of this size and also larger ones measuring $17-20 \times 5-6.5 \mu$, after four to five days in a damp chamber. It is also true that the European collections on *Carpinus* show a slightly narrower range of spore size ($15-20$ (23) \times $3.5-7 \mu$). Cultural data, which will be presented later, also show that there is in America a distinct species on *Ostrya*.

On the information available, and until further cultural data can be obtained, it seems best to arrange the various synonyms under three species occurring upon the three genera as follows:

MELANCONIS XANTHOSTROMA (Mont.) Schroet. Krypt.-Fl. Schles. 2: 441. 1897.

Sphaeria xanthostroma Mont. Ann. Sci. Nat. II. 1: 301. 1834.

Valsa chrysostroma Fries, Sum. Veg. Scand. 412. 1846.

Valsa xanthostroma (Mont.) Tul. Ann. Sci. Nat. IV. 5: 117. 1856.

Valsa bitorulosa Berk. & Br. Ann. & Mag. Nat. Hist. III. 3: 367. 1859.

Valsaria bitorulosa (Berk. & Br.) de Not. in Rab. Fung. Eur. 932.

- Melanconis chrysostroma* (Fries) Tul. Fung. Carp. 2: 125. 1863.
- Diaporthe hyperopta* Nit. in Otth, Nachtr. 6, Mittheil. nat. Ges. Bern, 1868: 47.
- Diaporthe carpinicola* Fuckel, Symb. Myc. Nachtr. 2: 37. 1873.
- Diaporthe decipiens* Sacc. Fung. Ven. 4: 6. 1875.
- Diaporthe nigro-annulata* Kunze, in Kunze. Fung. Sel. 122. 1875.
- Sphaeria carpinigera* Berk. & Curt. in Curt. Herb.
- Diatrype carpinigera* Berk. & Curt. Grevillea 4: 96. 1876.
- Diaporthe Kunzeana* Sacc. Fung. Ven. 5: 180. 1876.
- Cryptospora bitorulosa* (Berk. & Br.) Niessl, Hedwigia 16: 119. 1877.
- Cryptospora nigro-annulata* (Kunze) Rehm in Thüm. Myc. Univ. 2063. 1881.
- Diaporthe bitorulosa* (Berk. & Br.) Sacc. Syll. Fung. 1: 608. 1882.
- Diaporthe Carpini* Sacc. nec Fuckel, Syll. Fung. 1: 607. 1882 (Myc. Ven. Spec. 137).
- Diaporthe mucosa* Wint. in Sacc. Syll. Fung. 1: 609. 1882.
- Diaporthe carpinigera* (Berk. & C.) Sacc. Syll. Fung. 2, Add. XLVIII. 1883.
- Diaporthe Ellisii* Rehm, Bull. Torrey Club 10: 89. 1883.
- Valsa Ellisii* Rehm in Ellis & Ev. N. Am. Fungi 1567. 1886.
- Diaporthe farinosa* Peck, N. Y. State Mus. Rep. 40: 69. 1887.
- Melanoconis bitorulosa* (Berk. & Br.) Ellis & Ev. North Am. Pyrenom. 522. 1892.
- Diaporthe leucostoma* Feltg. in Höhnelt, Sitz. Acad. Wiss. Wien 115: 1251. 1900.
- Chorostate decipiens* (Sacc.) Trav. Fl. Ital. Crypt. 2: 208. 1906.
- Chorostate Kunzeana* (Sacc.) Trav. Fl. Ital. Crypt. 2: 200. 1906.
- Chorostate mucosa* (Wint.) Trav. Fl. Ital. Crypt. 2: 192. 1906.
- Chorostate suspecta* Sacc. Ann. Myc. 11: 115. 1913.
- Discodiaporthe xanthostroma* (Mont.) Petr. Hedwigia 62: 293. 1920.

Melanconis Ostryae (Dearn.) comb. nov.

- Diaporthe ostryigena* Ellis & Ev. in Herb. (N. Am. Fungi 3420) 1896.
- Diaporthe Ostryae* Dearn. Mycologia 18: 246. 1926.

Melanconis flavo-virens (Otth.) comb. nov.

Valsa flavo-virens Otth. Nachtr. 6, Mittheil. Nat. Ges. Bern. 1868: 47.

Diaporthe sulphurea Fuckel, Symb. Myc. 205. 1869.

Diaporthe affinis Sacc. Michelia 1: 28. 1878.

Valsa olivaestroma Cooke, Grevillea 14: 48. 1886.

Diaporthe elaeostroma (Cooke) Berl. & Vogl. Syll. Add. 107. 1886.

Chorostate sulphurea (Fuckel) Trav. Fl. Ital. Crypt. 2: 209. 1906.

Chorostate affinis (Sacc.) Trav. Fl. Ital. Crypt. 2: 209. 1906.

Discodiaporthe sulphurea (Fuckel) Petr. Hedwigia 62: 291. 1921.

Melanconis sulphurea (Fuckel) Petr. Ann. Myc. 21: 321. 1923.

CONIDIAL STAGE

A number of collections examined have shown associated conidial stages. Table 1 will serve as a reference for these associations.

From this table it can be seen that three types of conidia have been found associated with this species. First, a small cylindric to allantoid, one-celled, hyaline form measuring $(5.5) 8-14 \times 1.5-2.5 \mu$. This type was found on both European and American material, but always on *Carpinus*.² Second, a larger, fusoid to clavate, one-celled, hyaline type measuring $17-27.5 \times 4-5 \mu$ and found only on American material on *Carpinus*. Third, a *Melanconium* type of pustule with ovoid, brown, one-celled conidia, $11-16 \times 5-10 \mu$ occurring on *Ostrya* in America and on *Carpinus* in Europe. *Melanconium triangulare* Ellis & Ev., although given as the conidial stage of *D. Ellisii*, is probably in error.

The associations of conidial stages with the various species of this group to be found in the literature are numerous and confusing. A brief survey of these will be considered here.

On *Carpinus*:

Melanconium bicolor beta ramulorum Corda.

Melanconium microsporium Nees.

² The *D. Bloxami* specimens are given as on *Fagus*, but seem to be *Melanconis xanthostroma* on *Carpinus*. These somewhat larger conidia may, however, belong to some other species.

TABLE I

| Collection | Cylindric, hyaline conidia | Fusoid, hyaline conidia | Ovoid, brown conidia |
|------------------------------------------------------------------------|----------------------------------|-------------------------------|----------------------------|
| Syd. Myc. March. 263, sub <i>Cryptospora bitorulosa</i> (C)..... | 8-10×2.5 | | |
| Syd. Myc. March. 2947, sub <i>Diaporthe Bloxami</i> (F?)..... | 11-14×2-2.5 | | |
| Rehm Asc. 980, sub <i>Diaporthe Bloxami</i> (F?)..... | 11-14×2-2.5 | | |
| Thüm. Myc. Univ. 469, sub <i>Diaporthe decipiens</i> (C)..... | 8-11×2-2.5 | | |
| Ellis N. A. F. 1567, sub <i>Diaporthe Ellisii</i> (C)..... | 8-11×2 | | |
| Wehm. Herb. 3647, sub <i>Melanconis hyperopta</i> (C)..... | 5.5-8.3×2-2.5 | | |
| Wehm. Herb. 3645, sub <i>Melanconis hyperopta</i> (C)..... | 10-12×1.5-2 | | |
| Wehm. Herb. 3625, sub <i>Melanconis hyperopta</i> (C)..... | 8-10×2.5-3 | 17-23.5×4-5 | |
| Rab. Fung. Eur. 2243, sub <i>Cryptospora bitorulosa</i> (C)..... | 9-12×2-2.5 | | |
| Wehm. Herb. 3624, sub <i>Melanconis hyperopta</i> (C)..... | | 18-27×4-5 | |
| Rab. Fung. Eur. 2243b, sub <i>Cryptospora bitorulosa</i> (C)..... | | | 11-14×7-10 |
| Syd. Myc. March. 984, sub <i>Diaporthe decipiens</i> (C)..... | | | 10.5-16×8-9 |
| Dearness Herb., July 6, 1904, sub <i>Diaporthe Ostryae</i> (O)..... | | | 11-15×5-7 |
| Wehm. Herb. 3828, sub <i>Melanconis Ostryae</i> (O)..... | | | 10-12×5-6.5 |
| Wehm. Herb. 3829, sub <i>Melanconis Ostryae</i> (O)..... | | | 11-13×5-6.5 |
| Ellis N. A. F. 1568, sub <i>Melanconium triangulare</i> (C).... | | | 5-6 μ diam. |

The host is represented by the capital initial, as *Carpinus* (C), *Ostrya* (O), *Fagus* (F).

This conidial stage was given by the Tulasnes (13, p. 125) as belonging to *Melanconis chrysostroma*. They state that on the surface of a covered ectostroma there are formed two types of conidia. One, *Melanconium*-like with ovate dark colored conidia, acute at one end and measuring $13-15 \times 10 \mu$, and a second "Cyttisporoid" type with ovate to linear oblong conidia, sometimes curved, hyaline, and $10-13 \times 3.5-5 \mu$.

Fuckel (5, p. 37) gives the spermagonia of his *Diaporthe carpinicola* as unilocular, tuberculiform, beneath the epidermis and with conidia which are elongate fusiform, one-septate, 2-3 guttulate, straight, hyaline and $10-12 \times 5 \mu$. The septation seems doubtful.

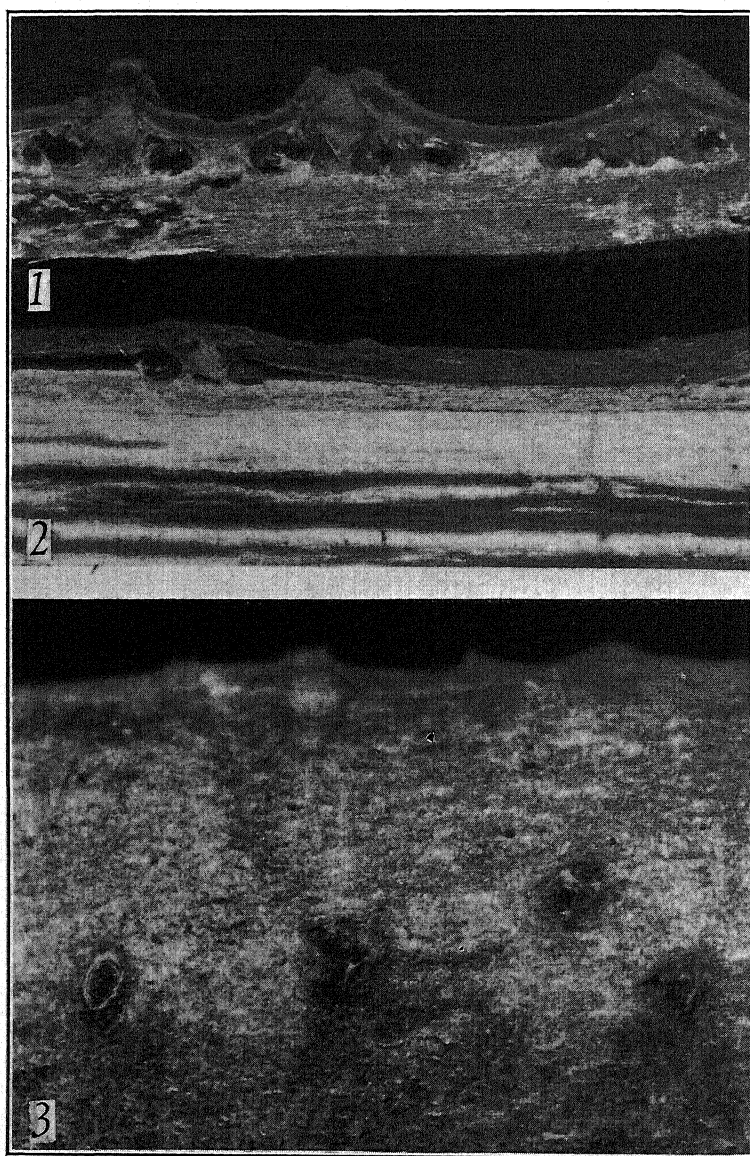


FIG. 1. *Melanconis* sp.

In Rab. Fungi Eur. 2243, Niessl gives out material containing hyaline conidia, which he gives (12, p. 119) as measuring $11-14 \times 4 \mu$ and as belonging to *Cryptospora bitorulosa* (*Diaporthe Kunzeana*). The writer finds these to be the typical cylindric hyaline conidia and measuring $9-12 \times 2-2.5 \mu$. In No. 2243b of this same exsiccati, he issues a *Melanconium* type of conidial stage which he says is connected with *Melanconis chrysostroma*, which in turn differs from his *Cryptospora* in the greenish-yellow stroma. Both these conidial stages agree with the Tulasne's descriptions of *M. chrysostroma*.

Cytispora sp. was cited by Ellis (2, p. 89) as the conidial association for *Diaporthe Ellisii*. The oblong, hyaline, 4-nucleate conidia, measuring $8-11 \times 2-2.5 \mu$ and occurring in orange colored masses, which he describes, are typical of the smaller conidial type on *Carpinus*.

Melanconium triangulare Ellis & Ev., which was later suggested by Ellis (3, p. 38) as a conidial stage of *D. Ellisii* undoubtedly belongs elsewhere for the triangular conidia are not similar to any of the conidial stages associated with this group.

Fusicoccum Kunzeanum was given by Saccardo (Syll. Fung. 1: 607) as the conidial stage of *Diaporthe Kunzeana* (*D. Carpini* Sacc. nec. Fuckel). It is described as having a depressed conic stroma beneath the periderm with a single locule and with oblong-fusoid, straight or curved conidia, measuring $10-11 \times 3-4 \mu$. These again seem to be the small cylindric conidial type.

In 1906, Höhnelt (6, p. 681) listed *Fusicoccum Carpini* as the conidial stage of *Diaporthe Carpini* Sacc. This is an error for *F. Carpini* was described as the conidial stage of *D. Carpini* Fuckel nec Saccardo, which is an entirely different species.

Melanconium deplanatum Speg.

Myxosporium deplanatum (Lib.) Sacc.

Discosporium deplanatum (Lib.) Höhn.

Höhnelt (7, p. 197) in his discussion of his new genus *Discosporium*, gives the above synonymy and points out that this species is the same as the conidial stage described by Fuckel for his *Diaporthe carpinicola*. He claims that there are perithecial stromata of *Melanconis chrysostroma* on Fuckel's exsiccati and that this conidial stage belongs to that species and not to *D.*

carpinicola, not recognizing the identity of the two perithecial stages. He also points out the identity of the conidia of this species with the "cystisporoid" conidia of the Tulasne's description and says that he has seen hyaline ovoid conidiae, $14 \times 10 \mu$ in these locules, which he considers to be immature *Malanconium* conidia.

Malacostroma irregulare (Died.) Höhn.

Cytospora carnea Ellis & Ev.

Dothiorella irregularis Died.

Höhnelt (8, p. 355) gives the above synonymy for the conidial stage of *Diaporthe farinosa* Peck. This *Diaporthe* was originally given as occurring on *Tilia*, but obviously is on *Carpinus*. These conidial stages occur on *Tilia*, have large tuberculate, multilocular stromata and conidia which are elongate fusoid, two-guttulate and $8-12 \times 2.5-3 \mu$. This is undoubtedly an incorrect guess.

On *Corylus*:

Myxosporium sulphureum Sacc.

This is given as the conidial stage of *Diaporthe sulphurea* Fuckel by Saccardo (Syll. Fung. 1: 625). The conidia are given as fusiform, inaequilateral, one-celled and $12-16 \times 5-6 \mu$. These conidia seem to be of the fusiform hyaline type found on *Carpinus* but are shorter than those obtained from American material on that host.

Discosporium sulphureum (Sacc.) Petr.

Petrak (10, p. 291) has pointed out the similarity between *Myxosporium sulphureum* Sacc. and *Discosporium deplanatum* (Lib.) Höhn, and places *M. sulphureum* in the genus *Discosporium*. Petrak is of the opinion that *Melanconium bicolor beta ramulorum*, occasionally found on *Carpinus*, has no connection with *M. xanthostroma*. He considers the conidial stages of both *M. xanthostroma* and *M. sulphurea* as a *Phomopsis* with an open cavity (*Discosporium*) and erects a new genus, *Discodiaporthe*, to accommodate these two species. In a later paper (11, p. 321) he concludes that this conidial stage is in reality a hyaline spored *Melanconium* and that the difference in the conidial stage between *Melanconis* and his *Discodiaporthe* is not of generic importance and therefore unites these two genera.

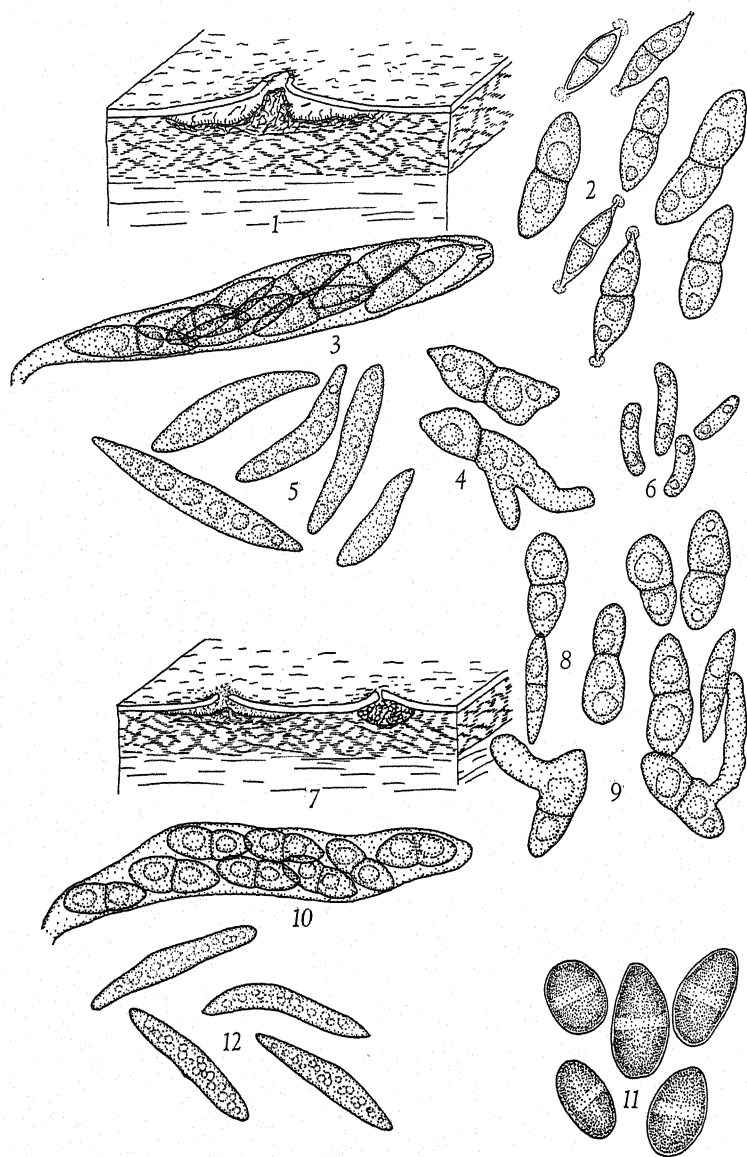
These reports in the literature seem to indicate that there is a

species on *Carpinus* with a *Melanconium* type of conidial stage with a dark brown, ovoid, one-celled, and a cylindric, hyaline, one-celled type of conidium. The reports of conidial stages on *Corylus* are more sparse but indicate one type of conidium which is fusoid, inaequilateral, hyaline and one-celled. A further consideration of these conidial stages and their relation to the American species will be postponed until after a presentation of the cultural data.

CULTURAL RESULTS

Melanconis xanthostroma (Mont.) Schroet., which name may be used tentatively for the American species on *Carpinus*, was the first to be cultured, from material collected near Ann Arbor, Michigan, in November, 1935. Sprays of ascospores were made onto nutrient agar on November 12 and again on December 7, 1935. No germination was evident in either case until after forty-eight hours, when a few spores showed short germ tubes. The spores became irregularly swollen (FIG. 2: 4) and measured $18-20 \times 5.5-6.5 \mu$. They put out from one to three germ tubes $3-3.5 \mu$ in diameter, from one or both cells. Growth from isolated ascospores was exceedingly slow on nutrient agar, but much more rapid on oat agar where colonies 1.5-2 cm. in diameter were produced in about two weeks. A rather abundant compacted cottony white mycelium was formed on the surface. The growth became yellow-green or gray-green with age. In old cultures, irregular pulvinate masses of compacted hyphae were formed on the surface, from which were exuded pinkish spore masses. The spores in these droplets were fusoid, one-celled, hyaline, often abnormally curved or bent and measured $16-25 \times 3.5-5 \mu$.

On May 2, 1936, autoclaved twigs of *Carpinus caroliniana* were inoculated from single ascospore cultures. Growth was very slow on twigs also appearing superficially, only after a month's incubation, as a whitish to yellowish cottony mycelium at the point of inoculation. After about six weeks, yellow-orange spore horns appeared at these points. Afterwards, more normal conidial pustules (FIG. 2: 1) were formed more rapidly over the entire surface. The ectostromata originate on the bark surface beneath the periderm and consist of a yellowish green prosenchyma. The

FIG. 2. *Melanconis* sp.

central portion grows upward and ruptures the periderm and becomes the erumpent disc which is olive-green in color. The basal portions spread out centrifugally, and on these flanks or the sur-

face of this portion, around the central sterile disc, the hymenium is formed. As a result the spore masses are pushed out at the sides of the central disc, not through it. The conidia (FIG. 2: 5) are variable in size and shape, especially so in old pustules or under unfavorable growth conditions. They are cylindric-fusoid to ellipsoid-fusoid, straight to curved or bent, one-celled, hyaline, show a single row of conspicuous droplets when fresh and measure from $16.5\text{--}30$ (37) \times $3.5\text{--}5\ \mu$. The spore masses are either pinkish or yellow at first, becoming dark olive brown when dry. These alpha conidia, as they appear to be, correspond to the fusoid hyaline type found twice in nature. Scores of pustules of all ages were examined in a search for the beta or cylindric type of conidium (FIG. 2: 6), commonly found associated with this species in nature, but none were found. In old pustules the alpha conidia may become narrower or shorter and approach the beta type in size, but these should not be considered as such. It is probable that the rather vigorous growth under the moisture conditions of the culture tubes is not favorable for the formation of the cylindric conidia, for in spite of their absence from culture, the writer is still of the opinion that they represent a second conidial type for this species.

Similar inoculations onto twigs of *Ostrya virginiana* made on July 3, 1936, gave very similar results. The conidial stromata tended to be somewhat smaller and the amount of spore production was greatly reduced but the stromata and conidia were of the same type, the latter measuring $15\text{--}23.5 \times 3.5\text{--}5.5\ \mu$.

Melanconis Ostryae (Dearn.) comb. nov.

The lack of any dark walled conidia in the life history of the species on *Carpinus caroliniana* and the occurrence of a *Melanconium* stage on type material of *Diaporthe Ostryae* from Dr. Dearness, suggested a closer consideration of this species on *Ostrya*. Several occurrences of a *Melanconium* in association with *Melanconis* (*Diaporthe*) *Ostryae* were soon found in the field. Three sets of spray cultures on nutrient agar were made, and single spores isolated from this material as follows:

3828. S. Ascospores from perithecia on *Ostrya virginiana* collected July 29, 1936, near Ann Arbor, Mich.

3828. *C. Melanconium* conidia from pustules on the same twigs as 3828 S.
3829. Ascospores from perithecia on *Ostrya virginiana* collected August 6, 1936, near South Lyons, Mich.

The ascospores (FIG. 2: 8) of *M. Ostryae* germinated within twenty-four hours by means of a single germ tube (FIG. 2: 9) some $3-4\ \mu$ in diameter. The germinating spores measured $15-18 \times 5.5-6.5\ \mu$. Growth, in this species, was also slow but much more rapid than in *M. xanthostroma*. On nutrient agar the growth was slow (about 4 cm. in five weeks) and a distinct circular colony was formed with a wrinkled marginal zone of appressed pubescent, white mycelium. The center of the colony turned gray-brown to tan with age, but did not show the yellowish or yellow-green tints of *M. xanthostroma*. On oat agar the growth was more rapid and irregular and stromata were formed sooner and in greater abundance. Blackish spore masses were exuded from these stromata. These conidia (FIG. 2: 11) were ovoid to ovoid-oblong, one-celled, olive-brown and measured $10.5-14 \times 6-7\ \mu$. These growth characters and the conidial formation were practically identical in each isolation (3828 S and 3829). In a few spore horns from young stromata of 3828 on oat agar, a second, or beta type of conidium was found. These conidia (FIG. 2: 12) were elongate-fusoid, one-celled, hyaline, irregularly granular and $19.5-25 \times 2.5-3.5\ \mu$. These conidia, which are similar to the alpha conidia of *M. xanthostroma* were rare, or entirely absent from the older spore horns and were never seen again in culture. This scarcity in culture may explain the failure to find beta conidia of *M. xanthostroma*.

The *Melanconium* conidia from *Ostrya* (3828 C) germinated within twenty-four hours by means of a single germ tube, $3-3.5\ \mu$ in diameter and gave rise to a colony similar in all respects to the ascospore isolations. The same type of stromata and the same *Melanconium* type of conidium were also obtained from these cultures.

Inoculations were made onto twigs of *Ostrya virginiana* on October 7, 1936, and onto *Carpinus caroliniana* on November 10 from all three of the isolations mentioned. The results were es-

entially the same in all cases. Growth and fruiting occurred equally as well on *Carpinus* as on *Ostrya*. Superficial, spherical, white to grayish stromata which exuded watery black spore masses were first formed in the moist tubes. The more normal ectostromata (FIG. 2: 7) were formed later on the surface of the bark cortex just beneath the periderm. A conidial hymenium is formed first on the flanks and eventually over the entire surface of this gray-green ectostroma which is usually filled with crystalline granules. At maturity there remains a very thin layer of light colored stroma with the hymenial layer. The mass of spores formed are pushed out through a pore like opening in the periderm as a coiled thread or ribbon of spores. The conidia (FIG. 2: 11) are oblong-ellipsoid to ovoid, one-celled, hyaline at first, but soon olive-brown, coarsely granular and usually with a light colored equatorial band about the cell. They measure $8.5-14 \times 6-7.5 \mu$.

In some cultures after the formation of conidial ectostromata, and usually on other portions of the twigs, there arose small spheric to conic ectostromata $150-250 \mu$ in diameter. These occasionally had slight shallow cavities with a few spores on their flanks, but were normally sterile and undoubtedly represent the initiation of perithecial pustules.

This production of a *Melanconium* conidial stage by the form on *Ostrya* indicates that there is a distinct species on this host. A careful study of what material was available on *Carpinus* and *Ostrya* indicates certain other correlated characters which may be outlined as follows:

M. xanthostroma on *Carpinus* has larger ($500-1200 \mu$ diam.) more strongly erumpent ectostromata (FIG. 1: 1) which often take on a more yellow-green color. The discs are generally larger ($300-800 \mu$) and more elongate. The spores are more variable in size; immature spores being $11-15 \times 3-5 \mu$, whereas fully mature spores reach $15-23 \times 4-7 \mu$. Growth in culture is very slow and shows yellow-green to olive shades. No brown conidia formed.

M. Ostryae on *Ostrya* has minute pustules with smaller ($200-600 \mu$) less strongly erumpent ectostromata (FIG. 1: 2) which are more gray-green in color. The discs are smaller ($200-400 \mu$)

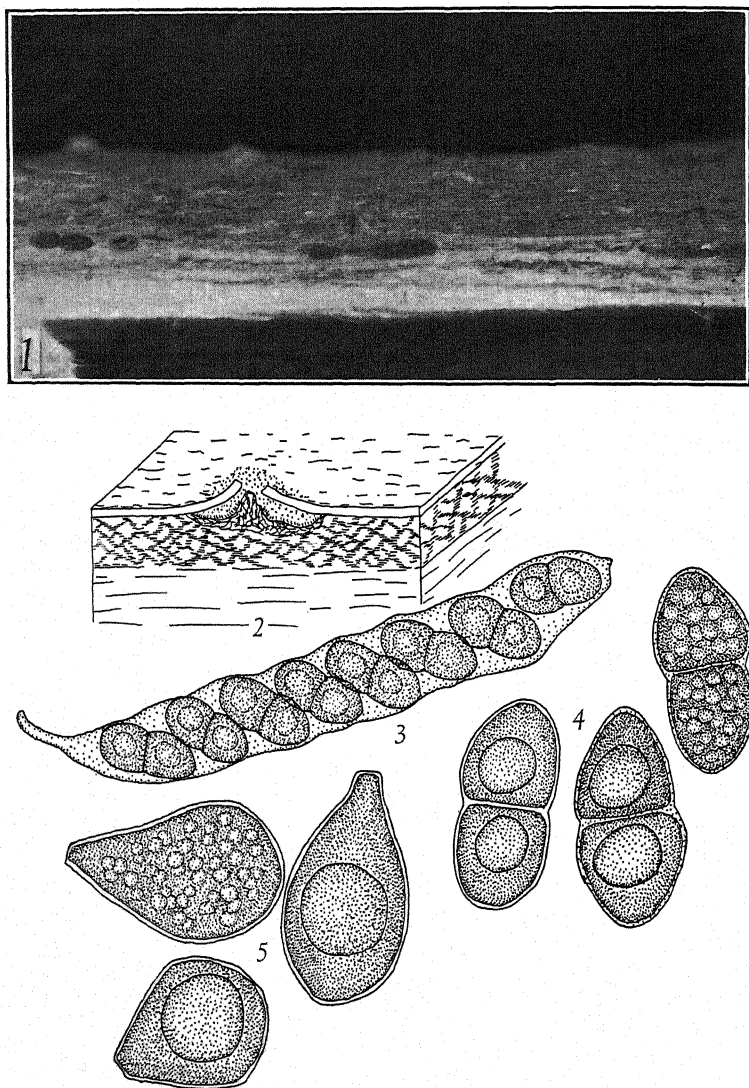


FIG. 3. *Melanconis* sp.

and more circular. The spores are not so variable, measuring $14-21 \times 4-7 \mu$, and often have one cell narrower and somewhat tapered. Growth in culture shows gray-brown to tan shades. Brown ovoid conidia are formed.

While collecting material for these studies, a *Melanconium* was also found on *Carpinus*, near Brighton, Michigan. Upon examination, this was found to be associated with a *Melanconis* with brown spores which has proved to be a new species, and is described here as follows:

***Melanconis platystroma* sp. nov.³** (FIG. 1: 3, FIG. 3: 1-5).

Appearing on the surface (FIG. 1: 3) as flattened circular pustules with a central conical papilla through which there is finally erumpent a truncate conic, gray to yellow-gray ectostromatic disc, 0.5-0.8 mm. in diameter. The cylindric ostioles are scarcely visible or barely erumpent through the disc. The perithecia are 400-500 μ in diameter, somewhat flattened, circinate beneath the ectostroma (FIG. 3: 1) in the upper bark cortex, which is unaltered or slightly entostromatic. The asci (FIG. 3: 3) are cylindric, pinched off at the base, about $200 \times 14-17 \mu$. The spores (FIG. 3: 4) are uniseriate or overlapping, blunt ellipsoid, two-celled, constricted and occasionally slightly bent at the septum, brown to olive-brown, coarsely granular when fresh, becoming uniguttulate, and $25-31 \times 12.5-14.5 \mu$. The spore wall is brown, but the fresh spore has a greenish tint due to the color of the granular content. The paraphyses are broad band-like but soon evanescent.

³ *Melanconis platystroma* sp. nov. Stromata in superficie comparantia sicut pustulae rotundae planae papilla conica centrali per quam discus ectostromaticus conicus truncatus canus vel luteo-canus 0.5-0.8 mm. diametro demum erumpit. Ostiola cylindrica haud facile manifesta vel vix per discum erumpentes. Perithecia sub ectostromate in cortici superficiali circinata, 400-500 μ diametro. Asci cylindrici, basi praemorsi, $200 \times 14-17 \mu$. Sporae uniseriatae vel imbricatae, obtuso-ellipsoideae, bicellulae, in septo constrictae et interdum leviter curvatae, fuscae vel olivaceo-fuscae, $25-31 \times 12.5-14.5 \mu$; sporae vivae crasse granulares demum uniguttulatae. Paraphyses ligamentis latis, similes mox evanescentes.

Stromata conidialia superficialia *Melanconii* pustulis similia cumulis sporarum nigris. Hymenium conidiale in lateribus ectostromatis conici pallide vel olivaceo-fusci sub periderma. Conidia sicut cumuli sporarum nigri exsudantia, angulato-globosa vel ovoidea vel pyriformia, unicellula, viridifusca et primo crasse granulata deinde fusca uniguttulataque, apiculata, $20-31 \times 16-18 \mu$, in conidiophoribus brevibus.

In ramis *Carpini carolinianae* in sylvis "Pleasant Valley" dictis, Brighton, Michigan, 21 October, 1936. Specimina typica in Herbb. Univ. Mich. et auctoris.

Conidial stage: On surface as *Melanconium*-like pustules with black masses of spores. Conidial cavities (FIG. 3: 2) borne on the flanks of a conic, pale to olive-brown ectostroma beneath the periderm. Conidia (FIG. 3: 5) exuded as black spore masses, angular-globose to ovoid or pyriform, one-celled, greenish-brown and coarsely granular at first, becoming brown and uniguttulate, apiculate, borne on short conidophores and measuring $20-31 \times 16-18 \mu$.

On branches of *Carpinus caroliniana*, Pleasant Valley Woods, Brighton, Mich., October 21, 1936. Type specimens deposited in University of Michigan Herbarium and in author's Herbarium.

Numerous attempts have been made to germinate both the ascospores and conidia of this species, but so far all of these have failed. Twigs with both perithecial and conidial pustules were matured in damp chambers and healthy growing spores of all ages of maturity were obtained. Suspensions consisting of a mixture of conidia and ascospores in sterile distilled water were treated in various ways and then sprayed onto agar plates, as follows, in order to induce germination:

1. Suspensions and plates placed at 40° and 60° C. for 24 hrs. and then removed to room temperature.
2. Suspensions and plates placed for twenty-four hours at 2° and 10° C. alternately with similar periods at room temperature.
3. Suspensions made in dilute solutions of KOH (0.5 per cent) and lactic acid (0.5 and 2.5 per cent) before spraying onto plates.
4. Suspensions made in a dilute infusion of *Carpinus* bark and sprayed onto plates.
5. Suspensions made in several high dilutions of Indol-acetic acid.

Both the suspensions and the plates were kept under observation for 10-20 days, when contaminations overran the plates, but not a single germinating ascospore or conidium was seen. A few spores on the lactic acid plates showed an exudation of hyaline droplets but no further development occurred. Suspensions were also

sprayed onto autoclaved twigs of *Carpinus* but no infection has been observed.

During the period that these twigs were in the damp chamber, perithecial pustules of *M. xanthostroma* also appeared. The *Melanconium* pustules were always associated with *Melanconis platystroma* perithecial pustules, however, and apparently belong to this species.

DISCUSSION

From the foregoing discussion we see that a tabulation of spore size suggests two species in this group, one on *Carpinus* and *Ostrya* and one on *Corylus*. Cultural studies of the American species show that there are two similar but distinct species, one on *Carpinus* and one on *Ostrya*, differing in the conidial stages. Only cultural studies of the European forms and of material from *Corylus* can definitely determine the final status of species in this group, but certain suggestions do arise.

In the first place, specific (or varietal) differences seem to be correlated with the host. Stromata on *Carpinus*, both from Europe and America, are very similar and both show a cylindric hyaline type of conidium associated with these stromata. In cultures of American material, on the other hand, only the fusoid hyaline type of conidium, which has been found associated with American material in the field, was obtained. The absence of the cylindric conidia may be due to the more vigorous growth in culture.

European writers, again, report a *Melanconium* stage, *M. bicolor beta ramulorum* as associated with the species on *Carpinus* and such association has been seen by the writer. It seems probable, therefore, that there is a European species or variety on *Carpinus* differing from the American one in the conidial stage and having brown *Melanconium* and hyaline cylindric conidia. These *Melanconium* conidia are very similar to those obtained in culture for *M. Ostryae*, but appear to have a somewhat greater diameter. The cylindric hyaline conidia as cited in European descriptions seem to have a greater diameter than those found in American material, but this is not borne out by actual European material.

In America a species occurs on *Ostrya* with brown *Melanconium*

conidia similar to, but with smaller diameters than, those of the European species on *Carpinus*. Its second conidial type is similar to the hyaline fusoid conidium of the American species on *Carpinus*.

No conidia from *Corylus* have been seen by the writer, but Saccardo reports such a conidial stage with fusoid conidia similar to those obtained in culture for *M. xanthostroma* and *M. Ostryae* but distinctly shorter, which suggests that cultural studies will reveal one or several distinct species or varieties on *Corylus*.

These conidial stages also suggest a reappraisal of certain generic lines. The American form of *M. xanthostroma* would not fall within the genus *Melanconis*, although it is obviously closely related to the other species, as *M. Ostryae*, which have a definite *Melanconium* stage with brown conidia. It would rather belong with certain species of *Cryptodiaporthe* with a definite ectostroma, such as *C. galericulata*, which is reported as having similar *Fusicoccum* and *Myxosporium* stages in Europe, although cultures from American material failed to give a conidial stage. Many other species of *Cryptodiaporthe* are reported to have similar conidial stages. It seems that this group at least of the genus *Melanconis* has arisen from a section of the genus *Cryptodiaporthe* by the coloration of one or the other types of conidia formed and by the increased development of the ectostroma limiting the hymenium to the flanks of this tissue. The increase in pigmentation has subsequently been extended to the ascospores and the stromatic hyphae in various species. *Melanconis marginalis* is another species with dilutely colored conidia which is very closely related to *M. Alni* which is reported with brown conidia in Europe.

LITERATURE CITED

1. Diedecke, H. 1915. Kryptogamen-Flora der Mark Brandenburg. 9, Pilze 7. 1-962. Leipzig.
2. Ellis, J. B. & Everhart, B. M. 1883. New species of Fungi. Bull. Torrey Cl. 10: 89-90.
3. ———. 1886. New species of fungi from various localities. Jour. Myc. 2: 37-42.
4. ———. 1893. New species of North American fungi from various localities. Proc. Acad. Nat. Sci. Phila. 1893: 128-172.
5. Fuckel, L. 1873. Symbolae Mycologicae. Zweiter Nachträge. 1-99.

6. Höhnelt, F. 1906. Fragmente zur Mykologie. II. Mitteilung. Nr. 64-91. Sitz. Akad. Wiss. Wien. 115: 649-695.
7. —. 1914. Beiträge zur Mykologie. Zeitschr. Garungsphys. 5: 191-215.
8. —. 1917. Zweite vorläufige Mitteilung mycologischer Ergebnisse (Nr. 107-200). Ber. Deut. Bot. Ges. 35: 351-353.
9. Montagne, C. 1834. Notice sur les Plantes Cryptogames récemment découvertes en France. Ann. Sci. Nat. II. 1: 295-307.
10. Petrak, F. 1921. Mykologische Beiträge. I. Hedwigia 62: 282-319.
11. —. 1923. Mykologische Notizen. Ann. Myc. 21: 182-335.
12. Rabenhorst, L. 1877. Fungi europaei exsiccati. Klotzschii herbarii vivi mycologici continuatio. Editio nova. Series secunda. Cent. 3 (resp. 23). Hedwigia 16: 117-126.
13. Tulasne, L. R. & C. 1863. Selecta Fungorum Carpologia. 2: 1-319. Paris.
14. Wehmeyer, L. E. 1933. The genus *Diaporthe* and its segregates. Univ. of Mich. Studies. Sci. Ser. 9: 1-349.

EXPLANATION OF FIGURES

FIG. 1. 1, radial section of perithecial stromata of *Melanconis xanthostroma* (Mont.) Schroet. on *Carpinus caroliniana*; 2, radial section of perithecial stromata of *Melanconis Ostryae* (Dearn.) on *Ostrya virginiana*; 3, surface view of perithecial stromata of *Melanconis platystroma*.

FIG. 2. 1, radial section of *Discosporium* type of conidial stage of *Melanconis xanthostroma* (Mont.) Schroet. as produced in culture; 2, ascospores of *Melanconis xanthostroma* (Mont.) Schroet. showing variation in size, shape and appendages; 3, ascus and ascospores of *Melanconis xanthostroma* (Mont.) Schroet.; 4, germinating spores of *Melanconis xanthostroma* (Mont.) Schroet.; 5, hyaline fusoid type of conidia of *Melanconis xanthostroma* (Mont.) Schroet.; 6, hyaline cylindric to allantoid type of conidia of *Melanconis xanthostroma* (Mont.) Schroet.; 7, radial section showing *Melanconium* stage and young perithecial ectostroma of *Melanconis Ostryae* (Dearn.) as produced in culture on *Ostrya virginiana*; 8, ascospores of *Melanconis Ostryae* (Dearn.); 9, germinating ascospores of *Melanconis Ostryae* (Dearn.); 10, Ascus and ascospores of *Melanconis Ostryae* (Dearn.); 11, ovoid brown type of conidia of *Melanconis Ostryae* (Dearn.); 12, fusoid hyaline type of conidia of *Melanconis Ostryae* (Dearn.).

FIG. 3. 1, radial section of perithecial stromata of *Melanconis platystroma*; 2, radial section of conidial stroma of *Melanconis platystroma* as formed on *Carpinus* in culture; 3, ascus and ascospores of *Melanconis platystroma*; 4, ascospores of *Melanconis platystroma*; 5, conidia of *Melanconis platystroma*.

NEW OR NOTEWORTHY FUNGI FROM PANAMA AND COLOMBIA. I

G. W. MARTIN

(WITH 29 FIGURES)

Haplosporangium lignicola sp. nov.

Mycelio denso, albido demum dilute ochraceo; conidiophoris subulatis, brevibus, indivisis vel ramosis, continuis; conidiis globosis, nutantibus, tunica papillata vel rugosa, 11–15 μ diam.

Mycelium forming a dense, appressed turf, at first white, becoming pale ochraceous with age; hyphae slender, 2–3 μ in diameter, at first nonseptate, later giving rise to numerous conidiophores and becoming septate as the protoplasm is diverted into these structures, but dividing into short, thickened segments only in old cultures; conidiophores awl-shaped, simple or branched, often proliferating, variable in size but the unbranched ones mostly 40–60 μ in length and 6–8 μ in diameter at the swollen base, tapering to 1.5–2 μ at the tip; conidia globose, tuberculate, finally rugose, with dense contents and a thick hyaline wall, mostly 11–15 μ in diameter, averaging 13.5 μ .

Colombia: Dept. Magdalena, Sierra Nevada de Santa Marta, alt. 1250–1500 m. On rotten wood, collected August 11, 1935, and placed in moist chamber the following fall.

The genus *Haplosporangium* was based by Thaxter (Bot. Gaz. 58: 362. 1914) on two species, both cultured from dung. One species, *H. bisporale*, bears two spores in many of the so-called sporangia, which are smooth-walled. It was secured from several localities. The other, *H. decipiens*, with rough-walled, undivided conidia, was found only on dung of *Selenodon* from Haiti and has apparently not been discovered since. The reproductive structures are referred to by Thaxter as sporangia and are almost certainly homologous with the sporangia of other members of the Mucorales, but since they are not divided into spores internally in either *H. decipiens* or *H. lignicola*, and not definitely so in *H.*

bisporale, in the first two species at least they are clearly conidia in the sense in which I believe the term should be used.

H. lignicola is obviously closely related to *H. decipiens*, from which species it differs in several characters. The conidia (FIG. 1) are much larger, 11–15 μ as compared with 8–10 μ , although there are a few smaller ones and a few larger, the extremes observed being 9 μ and 18 μ . The conidial wall is at first tuberculate (FIG. 2), and retains evidence of its tuberculate character even in the later, more rugose stages. The conidiophores, predominantly simple in young cultures (FIG. 3, 4, 5) betray an increasing tendency to branch as the culture becomes older (FIG. 6) and in old cultures exhibit extensive proliferation (FIG. 7, 8). The mycelium shows less tendency to become broken up into short, thickened segments than in *H. decipiens*, although in old cultures this development is not uncommon.

The conidia break away at maturity and germinate at once under suitable conditions by the production of one to several mycelial filaments which are definitely constricted where they pass through the conidial wall (FIG. 9). The fungus grows readily on all common laboratory media. Cultures have been deposited with the American Type Culture Collection, Chicago, and the Centraalbureau voor Schimmelcultures, Baarn.

DIPODASCUS ALBIDUS Lagerh.

This curious fungus was originally described from the mountains of Ecuador, where it was growing intermingled with numerous other organisms in the slime-flux exuding from a wounded bromeliad. A decade later, Juel found it in Sweden, growing in similar fashion on fallen birches. These two curiously scattered collections are the only ones reported thus far. It is, therefore, of interest to add to the record the collection from the Sierra Nevada de Santa Marta of Colombia (Hacienda Cincinnati, 1250–1500 m., August, 1935. G.W.M. 3855). The fungus was growing on a fallen, but scarcely decayed branch which may still have had some sap in it, and had the appearance of a soft *Sebacina*, for which it was collected. Its true nature was not recognized until fourteen months later, and while attempts were made to culture it, it is scarcely surprising that these met with no success. The micro-

scopic characters differ in no significant respect from those described and illustrated by Lagerheim in his original publication (Jahrb. Wiss. Bot. 24: 549-565. 1892) except that no oidia were observed.

The only other species of *Dipodascus* is *D. uninucleatus*, recently described from Canada by Biggs (Mycologia 29: 34-44. 1937). This lacks oidia but its growth characters and general habit seem to mark it as clearly distinct from the Colombian material. The nuclear condition, which is the fundamental basis for separating the two species, cannot, of course, be determined satisfactorily from dried material.

TRICHOCOMA PARADOXA Jungh.

This species is widely distributed in the warmer parts of both hemispheres but is apparently not common. Dodge (Ann. Myc. 27: 152. 1929) notes collections in the new world from South Carolina, Puerto Rico and Brazil only. To this list may be added Panama. It was growing laterally on a fallen, mossy log in the forest south of the Llanos del Volcan, Province of Chiriqui, 1200-1350 m. (July 14, 1935. G.W.M. 2792). Both Dodge and Boedijn (Ann. Jard. Buitenz. 44: 243. 1935) agree that there is but a single species so far as known. The genus was made the type and only representative of the family Trichocomaceae by E. Fischer (Engler and Prantl 1¹: 310. 1897). Boedijn, on the basis of careful study, includes the genus in the Onygenaceae. Clements and Shear (Genera of Fungi 144. 1931) had previously done the same thing, but place the family in the Tuberales, whereas Boedijn retains it in the Plectascales. So far as can be decided by examination of mature specimens, Boedijn's disposition of the family is distinctly preferable.

Spore measurements, according to Dodge, are $6 \times 5 \mu$; Boedijn gives them as $5.5-7 \times 3.5-6 \mu$. In the Panama collection the fully matured spores measure $7-7.5 \times 5-6.5 \mu$, averaging $7.4 \times 6.1 \mu$. Numerous smaller immature spores were present in all mounts but could be eliminated by their capacity to take a phloxine stain, while the mature spores retained their bright brown color.

HYALORIA PILACRE A. Möller

This species, described by Möller (Protobasidiomyceten 137.

1895) from Brazil, was until recently the sole representative of its genus and family and the only known angiocarpous fungus with cruciate-septate basidia, corresponding in its angiocarpous character with the Phleogenaceae of the auriculariacean series. S. Killermann has recently described from Germany (Ber. Deutsch. Bot. Gesell. 54: 165. 1936) what he regards as a second species of the genus, illustrating it with photographs which convey almost nothing and drawings which are, to say the least, crude and confusing. He did, however, examine what he believes to be one of Möller's specimens and notes certain helpful corrections to Möller's description.

What I regard as Möller's species was found on a decaying palm stem in the Sierra Nevada de Santa Marta (Hacienda Cincinnati, 1250-1500 m., Aug. 22, 1935. G.W.M. 3616). The fructifications are much smaller than those described by Möller, few exceeding 1 cm. in height and the majority under 5 mm., and occur singly or in small groups rather than in the dense clusters he illustrates (l.c. pl. 1, f. 3) but microscopically the agreement is satisfactorily close.

Study of soaked specimens, supplemented by that of a few basidiocarps preserved in formal-acetic alcohol and imbedded, sectioned and stained with iron-alum haematoxylin permits certain additions and corrections to be made to our knowledge of this unique species.

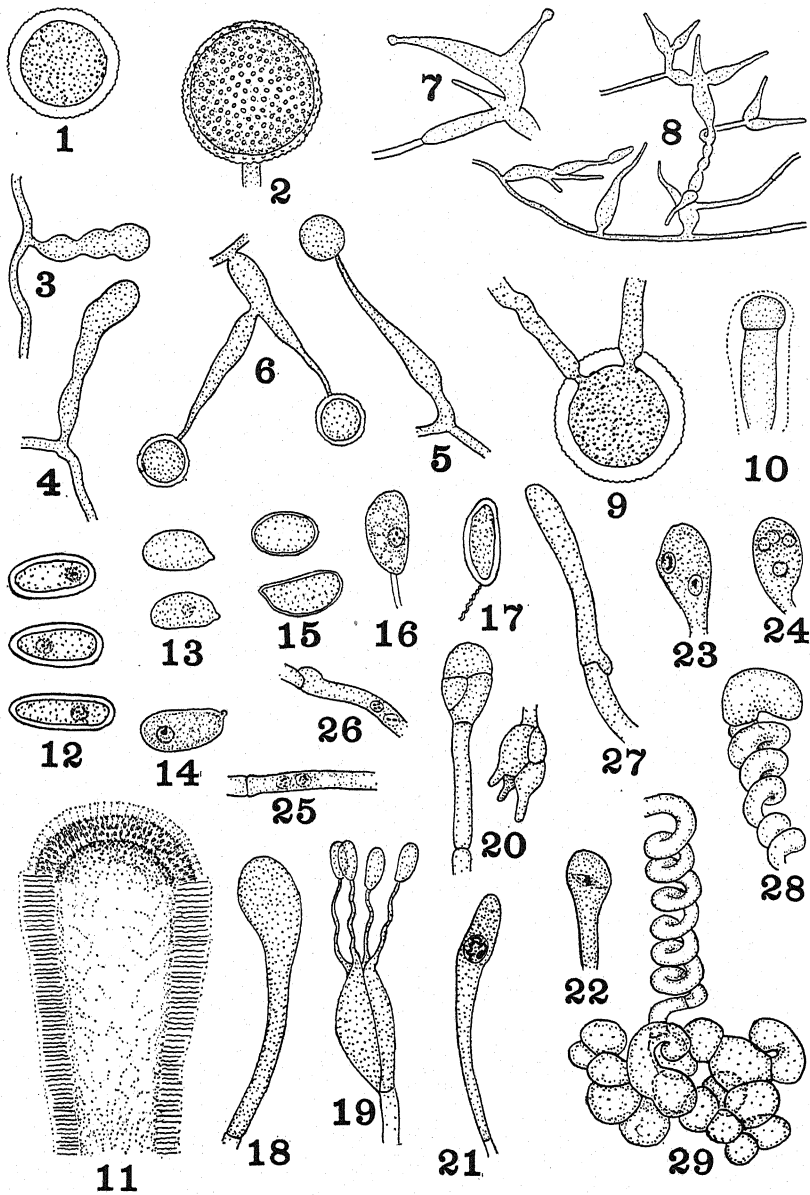
The dried basidiocarps are ochraceous yellow, extremely hard and horny, but the stalk and head are sharply defined. They soak up readily, becoming pure white, as they were when collected. The head remains relatively firm and opaque, the stalk somewhat less so, and the whole is surrounded by an envelope of transparent jelly which is thick about the stalk but much thinner above (FIG. 10). Longitudinal median sections of the preserved material (FIG. 11) show the body of the stalk to be composed of irregularly arranged hyphae with only a suggestion of longitudinal orientation and much interhyphal space. At the periphery, especially above, there is a fairly dense layer of coarse hairs. The hymenium occupies a dome-shaped area at the top and is composed of radiating, long-stalked, pyriform basidia, interspersed with long, sterile hairs which project above the basidia to a height somewhat less

than that of the hymenial layer. Beneath the hymenium is a very dense subhymenial layer, containing numerous swollen, vesicular cells, which gradually merges with the stalk below.

Möller (l. c. 138) refers to the hymenium, and again, in the formal description (p. 173) says: "Die tief unter der Oberfläsche, aber in einer Schicht angelegten Basidien. . . ." Gäumann (Vergl. Morph. Pilze 485. 1926) says, however, that the basidia are arranged irregularly, "nicht zu Hymenium vereinigt." Since Gäumann's account is based on that of Möller, it is difficult to discover the justification for such a statement. Certainly, in *Hyaloria* the hymenium is quite as clearly defined as it is in the majority of the tremellaceous fungi.

Möller describes the spores as "länglich ovalen," $7\ \mu$ in length, and notes the lack of apiculi. Killermann, in reexamining them, found them to be $8-10 \times 4\ \mu$. They occur in a dense mass above the hymenium, but retained within the gelatinous upper layer, and are wholly unlike the spores of other tremellaceous fungi. I find them $8.5-10 (-12) \times 4-4.5 (-5)\ \mu$, the homogeneous interior surrounded by a hyaline, refractive wall up to $1\ \mu$ thick (FIG. 12). Stained spores show a single nucleus, sometimes in the center, but often at one end. Young basidiospores can be found, however, which are thin-walled and with a definite apiculus (FIG. 13, 14) as well as various intermediate stages between such young spores and the mature, thick-walled spores (FIG. 15), suggesting that after separation from the basidia the spores continue to develop at the expense of the gelatinous matrix in which they are imbedded, somewhat as in certain Gasteromycetes, although there is no evidence of nurse hyphae. The transformation of the spore may begin while it is still attached to the epibasidium and in spite of the definite apiculus, it is obvious that the spores are not violently discharged, but are detached by the breaking of the epibasidium some distance below the point of attachment (FIG. 17). This, again, is suggestive of what happens in many Gasteromycetes, and serves to emphasize the true angiocarpous nature of the species.

The basidia, as stated, are extraordinarily long-stalked at first (FIG. 18). Later a septum appears at the base of the enlarged terminal portion and four longitudinal segments are cut out, each



FIGS. 1-9, *Haplosporangium lignicola*; 10-27, *Hyaloria Pilacre*;
28-29, *Hobsonia gigaspora*.

of which produces a rather slender epibasidium (FIG. 19) which, unlike those of most of the Tremellales, bears no clearly defined sterigma at the tip (FIG. 16). While the great majority of the basidia are typically cruciate-septate, irregularities in septation are not uncommon (FIG. 20).

Cytologically, the development, so far as followed, is in entire accord with that of other members of the group. A large fusion nucleus (FIG. 21) undergoes two successive divisions, resulting in four nuclei (FIG. 22-24), one of which presumably enters each spore, although the actual passage has not been seen. The mycelium is regularly binucleate (FIG. 25, 26). Clamp connections were not certainly seen in the subhymenium or the interior of the stalk, but may readily be observed on the peripheral hairs of the stalk (FIG. 26, 27).

HELICOSPORIUM LUMBRICOPSIS Linder.

In moist chamber on decaying palm stem collected at edge of Llanos del Volcan, Chiriqui, about 1350 m., July 14, 1935. G.W.M. 2791 b. Reported by Linder (Ann. Missouri Bot. Gard. 16: 284. 1929) from Florida, Venezuela and British Guiana. The "faint, pink tinge" mentioned by Linder was very apparent in the living fungus.

HOBSONIA GIGASPORA Berk.

Exceedingly abundant in the mountains of Chiriqui above 1500 m. and in the Sierra Nevada de Santa Marta at 1500-2200 m. The favorite substratum seems to be decayed stems of bamboo in both localities, but the fungus occurs on various kinds of wood, and was collected once on dead palm leaves. The sporodochia, in the better developments, are strikingly cupulate, and the conidio-phores, while sometimes merely loosely coiled as shown in Linder's figure (Ann. Missouri Bot. Gard. 16: pl. 28, f. 8. 1929) are often tightly wound in a close spiral (FIG. 28). The proliferation of the spores begins at a very early stage in their development, explaining the curiously irregular, knotted appearance they present (FIG. 29). The identification of this and the preceding species has been verified by Dr. Linder.

EXPLANATION OF FIGURES

With the exception of fig. 10, all outlined with camera lucida and reproduced at approximately the magnifications given in each instance. Unless otherwise stated, drawn from soaked material in 3 per cent KOH and Phloxine.

Figs. 1-9, *Haplosporangium lignicola*. 1, mature conidium of average size, $\times 1200$; 2, conidium of exceptionally large size, immature, with thin wall, still attached to conidiophore, $\times 1200$; 3, 4, developing conidiophores, $\times 550$; 5, unbranched conidiophore with immature conidium, $\times 550$; 6, branched conidiophore with two nearly mature conidia, $\times 550$; 7, much-branched and proliferating conidiophore from old culture, $\times 550$; 8, group of same, $\times 250$; 9, germinating conidium, $\times 1200$.

Figs. 10-27, *Hyaloria Pilacre* A. Möll. 10, sketch of soaked specimen, $\times 7$; 11, Diagrammatic longitudinal section, drawn from slide of material fixed in formal-acetic-alcohol and stained with iron-alum haematoxylin, $\times 25$; 12, three mature, thick-walled spores; 13, two young, thin-walled, apiculate spores; 14, same, from fixed and stained material; 15, two spores with slightly thickened walls, apiculus still evident in lower; 16, thin-walled spore still attached to end of epibasidium, fixed and stained; 17, thick-walled spore with shrivelled epibasidium still attached, fixed and stained; 18, young basidium; 19, older basidium; 20, two basidia showing aberrant septation; 21, young basidium with fusion nucleus, fixed and stained; 22, first division of fusion nucleus, fixed and stained; 23, 24, two- and four-nucleate stages, fixed and stained; 25, internal mycelium with dicaryon, fixed and stained; 26, peripheral hair, with dicaryon and clamp connection, fixed and stained; 27, tip of peripheral hair with clamp connection. Figs. 12-27, $\times 1200$.

Figs. 28-29, *Hobsonia gigaspora* Berk. G.W.M. 3758 (Colombia). 28, conidiophore, with conidial primordium; 29, later stage, showing proliferation of primordium. Figs. 28-29, $\times 550$.

STUDIES IN THE SEXUALITY OF THE HETEROBASIDIAE¹

HORACE L. BARNETT²

(WITH 3 FIGURES)

In the present work an attempt has been made to study the growth in culture and the sexuality of various species of the orders Auriculariales and Tremellales. The species included were *Auricularia Auricula-Judae* (Fries) Schröt., *Exidia glandulosa* (Bull.) Fries, *E. recisa* (Ditm.) Fries, *E. saccharina* Fries and *E. nucleata* (Schw.) Burt.

The literature concerning the Heterobasidiae, other than from a taxonomic standpoint, is scarce. Several writers have reported the germination of spores in culture for some of the species. Shear and Dodge (16) and Kniep (10) are the only investigators who have reported work on the sexuality of any species of this group. Cytological work has been published by Rogers (14, 15), Neuhoﬀ (12), and Whelden (23, 24, 25, 26).

MATERIALS AND METHODS

The collections of the species studied in culture and from which monospore cultures were obtained are shown in Table 1.

In the records of spore sizes in Table 1, the first and last numbers are the extremes and the numbers in parentheses are the means. Twenty spores of III, VI and VII, and 100 spores each of I, IV, V and VIII were measured.

Two fruit bodies from collection V of *A. Auricula-Judae* were selected and designated as Va and Vb. These had already been

¹ This paper represents an abbreviation from a thesis presented in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Botany of Michigan State College, East Lansing, Michigan.

² The writer wishes to acknowledge his indebtedness to Dr. E. A. Bessey under whose supervision these investigations were conducted.

removed from the host wood when received and it was not possible to determine how far apart they had been growing. From *E. glandulosa* II, two fruit bodies (IIa and IIb) were selected from the same log at a distance of two inches apart. The only collection of *E. saccharina* was growing on a stick about 12 inches long. Two fruit bodies from this were selected and designated as Ia and Ib. Only one fruit body was selected from each of the other collections.

TABLE 1

DATA CONCERNING THE COLLECTIONS USED THROUGHOUT THE EXPERIMENTS

| Species | Collection number | Place of collection | Date | Host | Spore size |
|----------------------------|-------------------|----------------------------------|---------------------|------------|---------------------------------------------|
| <i>A. Auricula-Judae</i> | I | Adirondacks, N. Y. ³ | 8/23/35 Received | Fir? | 10.5-(14.6)-17.5×4.8-(5.4)-7 μ |
| " | III | Lincoln, Nebr. ⁴ | 11/7/35 | Deciduous | 11.8-(13.5)-15.5×4.8-(5.2)-5.7 μ |
| " | IV | Chapel Hill, N. C. ⁵ | 7/6/35 Received | Oak | 8.8-(11.9)-14.8×5.2-(5.6)-6.6 μ |
| " | V | Lincoln, Nebr. ⁴ | 10/28/35 | Deciduous | 8.8-(12.4)-14.4×4.4-(5.2)-6 μ |
| " | VI | Iowa City, Iowa ⁶ | 9/2/36 | " | 10.5-(13.1)-15.2×4.8-(5.2)-5.7 μ |
| " | VII | Iowa City, Iowa ⁶ | 9/3/36 Received | Ash | 11.3-(13.3)-14 \times 4.8-(5.5)-6.2 μ |
| " | VIII | Fort Collins, Colo. ⁷ | 1/5/37 | Fir | 13.2-(15) -17.5×4.4-(5.4)-6.6 μ |
| <i>E. glandulosa</i> | I | E. Lansing, Mich. | 11/13/34 | Hickory | |
| "..... | II | E. Lansing, Mich. | 4/29/36 | Oak | |
| "..... | III | Lyons, Mich. | 5/30/36 | Hickory | |
| <i>E. recisa</i> | I | E. Lansing, Mich. | 3/28/36 | Oak | |
| "..... | II | Lyons, Mich. | 5/30/33 | Hickory | |
| "..... | III | E. Lansing, Mich. | 6/4/36 | Oak | |
| <i>E. saccharina</i> | I | Grayling, Mich. | 9/10/36 | White Pine | |
| <i>E. nucleata</i> | I | E. Lansing, Mich. | 7/9/35 | Maple | |

³ Collected by Dr. E. A. Bessey.

⁴ By courtesy of Dr. Leva B. Walker.

⁵ By courtesy of Dr. W. C. Coker.

⁶ By courtesy of Dr. G. W. Martin.

⁷ By courtesy of Prof. J. L. Forsberg.

All other specimens were collected by the author.

The most satisfactory method of obtaining spore deposits was similar to that used by Mounce (11). A portion of a fruit body was suspended from the cover of an agar plate and the spores were distributed by rotation of the cover. Well-isolated germinated spores were located by the high power objective of a binocular dissecting microscope. The spores and bits of the surrounding agar were picked out by the use of the eye of a specially prepared sewing needle and transferred to tubes of agar.

The best culture media for vegetative growth of all species were

potato dextrose agar and malt extract agar. The best media for the production of fruit bodies were potato dextrose agar with 1 gm. of peptone per liter, malt extract agar and prune-corn meal agar. The most typically shaped fruit bodies of *A. Auricula-Judae* were produced on moist, autoclaved fresh sticks of basswood and hickory.

RESULTS OF EXPERIMENTS

GERMINATION OF BASIDIOSPORES

The basidiospores of all species studied were one-celled at the time of discharge from the fruit body but some of the spores became two- or three-celled before germination (FIG. 1: 1, 10; FIG. 2: 1). The spores of all species, except *E. nucleata*, germinated readily and well on agar. In *A. Auricula-Judae* three methods of germination were observed. On agar they germinated by long stout germ tubes (FIG. 1: 3, 4) which grew directly into mycelium. Spores which fell back onto the fruit body produced secondary spores (FIG. 3: 4), similar in shape to the basidiospores. In distilled water the spores produced short slender germ tubes bearing sickle-shaped oidia (FIG. 1: 2A, B). In *E. glandulosa* the same three methods of germination were observed. In the same order these are illustrated by fig. 1: 12, 13, by fig. 1: 11 and by fig. 1: 9A, B, C. The same three methods were also observed in *E. nucleata* (FIG. 3: 1, 2, 3). Spores of *E. recisa* germinated only by means of long stout germ tubes (FIG. 2: 2, 3) which, in some cases, bore clusters of straight or slightly curved oidia (FIG. 2: 3). These oidia germinated on agar by means of secondary oidia or by producing normal mycelia directly (FIG. 3: 7). The method of germination in *E. saccharina* (FIG. 2: 10; FIG. 3: 5) was the same as in *E. recisa*. The oidia borne on the germ tubes germinated readily to produce normal monocaryon mycelia.

Fusions between young hyphae from two germinating spores were seen in *E. glandulosa* (FIG. 1: 17), *E. recisa* and *E. saccharina* (FIG. 2: 10). Abundant clamp connections were produced on dicaryon mycelia of all species included in this paper. These are illustrated as follows: *A. Auricula-Judae* (FIG. 1: 7), *E. glandulosa* (FIG. 1: 14), *E. recisa* (FIG. 2: 5), *E. saccharina* (FIG. 2: 6) and *E. nucleata* (FIG. 2: 13).

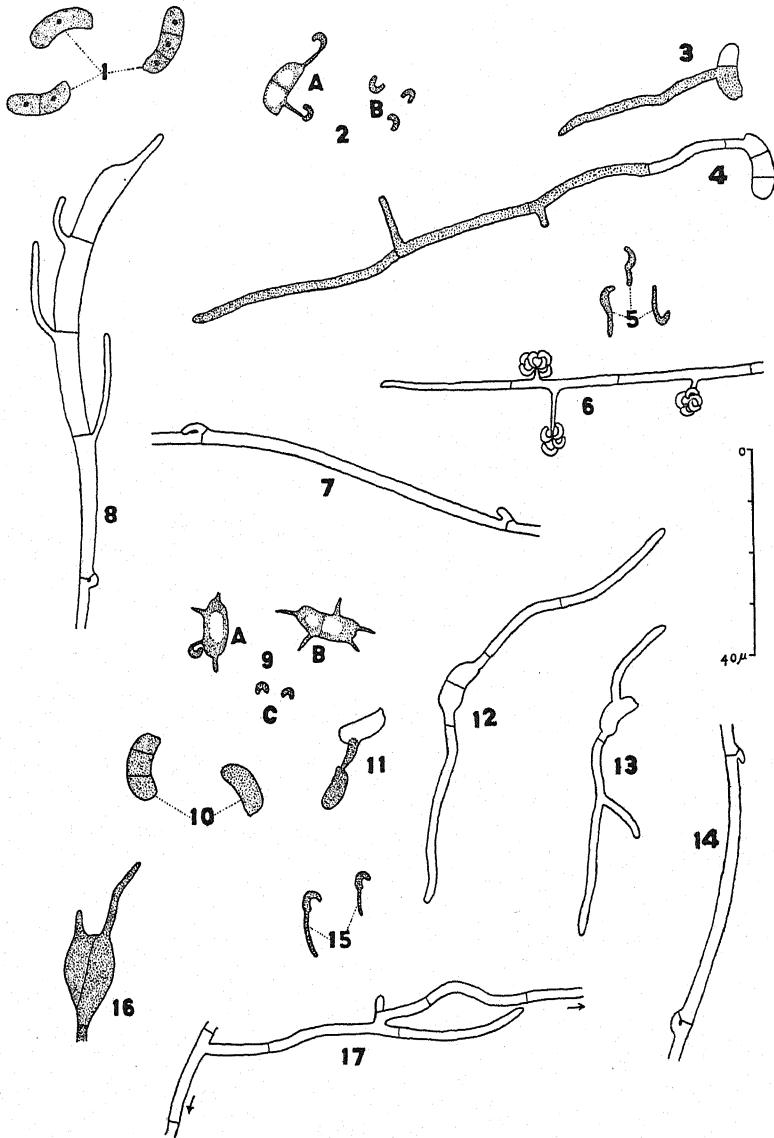


FIG. 1. *Auricularia Auricula-Judae* and *Exidia glandulosa*.

PRODUCTION OF OIDIA ON MYCELIA

Sickle-shaped oidia were borne in clusters on monocaryon mycelia of *A. Auricula-Judae* (FIG. 1: 6) and *E. nucleata* (FIG. 3: 6) and were also observed in small numbers in some of the monospore cultures of *E. glandulosa*. The oidia of these species were subjected to various conditions but no germination beyond the first stages were observed in *A. Auricula-Judae* (FIG. 1: 5), *E. nucleata* (FIG. 2: 12) and *E. glandulosa* (FIG. 1: 15). Oidia were observed only rarely in monocaryon cultures of *E. recisa*. Large masses of uninucleate oidia (FIG. 2: 8) were produced by most of the monospore cultures of *E. saccharina*. They were borne singly or in loose clusters (FIG. 2: 9), and germinated readily on agar to produce normal monocaryon mycelia. *E. saccharina* was the only species in which oidia were observed on dicaryon mycelia. In this case binucleate oidia (FIG. 2: 7) were borne singly on hyphae with clamp connections (FIG. 2: 6). Upon germination of these oidia clamp connections were formed on the first hyphae produced (FIG. 2: 11). From these, 37 single-oidial clusters were obtained. All produced normal dicaryon mycelia with clamp connections.

PRODUCTION OF FRUIT BODIES IN CULTURE

Dicaryon cultures of all species were grown on various media and under various conditions of temperature, light and moisture. Only one culture of *A. Auricula-Judae* and transfers from it developed fertile but atypical fruit bodies on agar (FIG. 3: 8). Normal basidia with four epibasidia (FIG. 1: 8) were found in young fruit bodies which later produced typical viable spores. Fruit bodies which were more typical in shape but which remained sterile (FIG. 3: 9) were developed on sterilized sticks of basswood and hickory.

In *E. recisa* a few typical four-celled basidia (FIG. 2: 4) were seen in only one dicaryon culture. In this case only a thin gelatinous layer was produced on the surface of the agar. No spores were seen. In several cultures (both dicaryon and monocaryon) there developed rounded, dark brown gelatinous bodies (FIG. 3: 10) which closely resembled normal young fruit bodies in appearance. It is thought that these gelatinous structures represented abortive fruit bodies which failed to develop basidia.

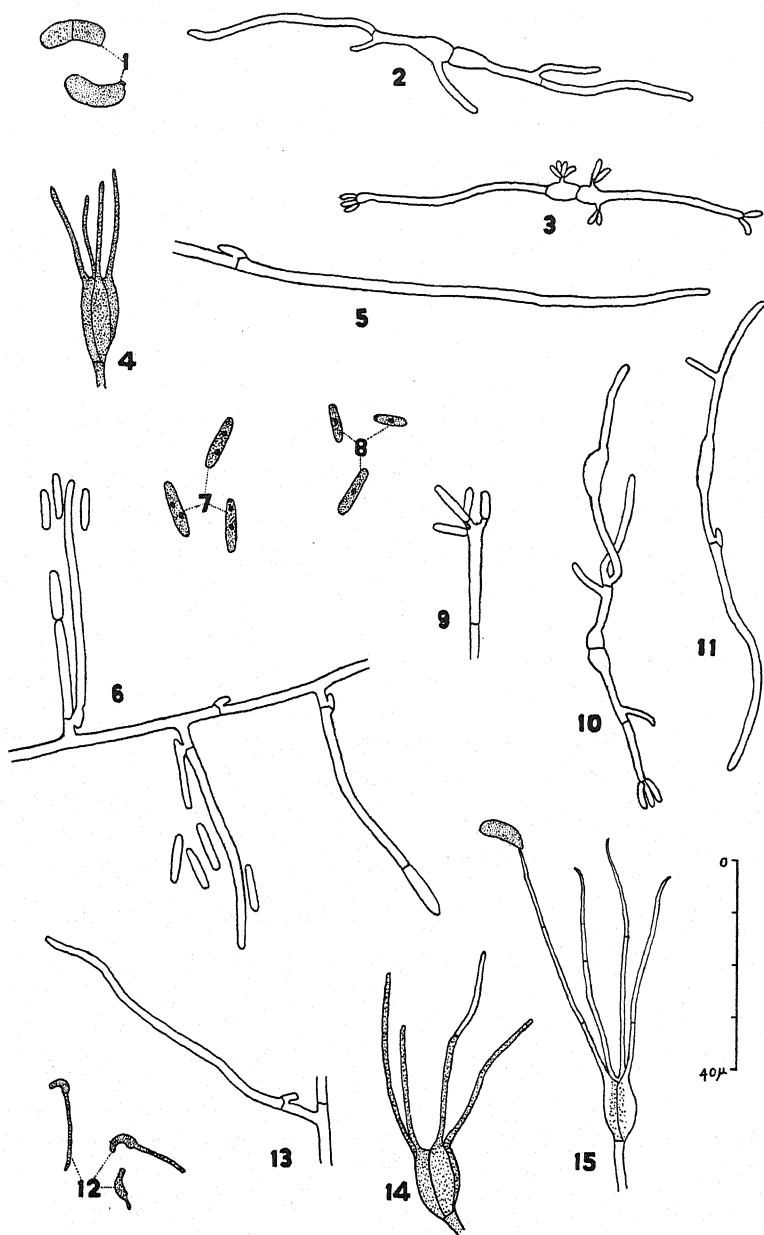


FIG. 2. *Exidia recisa*, *E. saccharina* and *E. nucleata*.

No signs of fruit body formation were seen in any dicaryon culture of *E. glandulosa*. Many young basidia were found in very small, gray gelatinous bodies in two monocaryon cultures. Several basidia were two-celled and rarely a four-celled basidium was seen. A few had produced two epibasidia (FIG. 1: 16) and a few typical basidiospores were seen in one culture. Although these cultures were checked thoroughly, using nuclear stains, no clamp connections were seen and all cells observed were uninucleate. This appears to be a case where fertile but quite atypical, poorly formed fruit bodies were produced by monocaryon mycelia.

Small white, cushion-like fruit bodies were produced in dicaryon cultures of *E. nucleata*. This was true for the multispore cultures and for some of the compatible pairings of monocaryon mycelia. Many four-celled typical basidia were present (FIG. 2: 14, 15). The longer epibasidia were often one or two-septate (FIG. 2: 14, 15). Typical viable spores were numerous on these fruit bodies. No signs of a central crystal body were seen in any of the fruit bodies in culture.

SEXUALITY

Because the species studied in the present work showed no other distinguishable difference between monocaryon and dicaryon mycelia and because the production of fruit bodies was rare, the presence of clamp connections alone was taken as an indication of true dicaryon mycelium. By staining mycelia both with and without clamp connections early in the course of this investigation, the correctness of this assumption was determined for the species in question.

The monospore cultures from each fruit body were given Arabic numbers, but without duplication of the numbers in other fruit bodies. Each fruit body was given a Roman numeral corresponding to the number of the collection. The monospore cultures from each fruit body were paired in all combinations on agar slants in 15 mm. test tubes. After about two weeks the line of contact between the two mycelia was examined for the presence of clamp connections. When clamps were found the two mycelia were said to be compatible. In several cases short branches were seen at septa and these may have been abortive clamp connections, but un-

less complete and definite clamps were seen the results were considered as negative. When irregular results were obtained the pairings were repeated. In all tables the + sign indicates the presence of clamp connections and the — sign indicates their absence.

A. AURICULA-JUDAE

Twenty-two monospore cultures from fruit body I were paired in all possible combinations and the results are given in Table 2. The cultures fell into two groups, based upon the production of

TABLE 2

A. Auricula-Judae. RESULTS OF PAIRING 22 MONOSPORE CULTURES OF FRUIT BODY I

Pairings between members of the same sexual phase are not shown.

| | 4 | 5 | 6 | 8 | 9 | 10 | 12 | 13 | 15 | 16 | 17 | 19 | 22 | 24 |
|----|---|---|---|---|---|----|----|----|----|----|----|----|----|----|
| 1 | + | + | + | + | + | — | + | — | + | + | + | + | — | + |
| 3 | + | — | + | + | + | + | + | + | + | + | + | + | + | + |
| 7 | + | + | + | + | — | + | + | + | + | + | + | + | + | + |
| 18 | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 20 | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 21 | + | + | + | — | + | + | + | + | + | + | + | + | + | + |
| 23 | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 25 | + | + | + | + | + | + | + | + | + | + | + | + | + | + |

clamp connections in certain combinations. Throughout this paper these groups are referred to as "sexual phases." The two sexual phases were designated as A and a. When members of the same sexual phase were paired no clamp connections were produced. Clamp connections were found in all but six of the 112 pairings between A and a.

The monospore cultures of each of the other fruit bodies were paired in all combinations as follows: 19 from III, ten from III F₁ (a fruit body grown in culture), 11 from IV, 11 from Va, seven from Vb, nine from VI, six from VII and nine from VIII. The

results of the pairings of fruit body IV are given in Table 3. In all these fruit bodies, except VIII, the results were very regular. Clamp connections were found in every pairing between members of different sexual phases while none were present in any pairing between members of the same sexual phase. The results of pairings of cultures from fruit body VIII showed that clamp connections were present in only one (502×505) of the 36 pairings. Clamps were present in the fruit body but none were found in a culture arising from many spores. The results obtained from fruit

TABLE 3

A. Auricula-Judae. RESULTS OF PAIRING 11 MONOSPORE CULTURES OF FRUIT BODY IV

- = presence of aversion.

| | 151 | 152 | 155 | 157 | 158 | 161 | 153 | 154 | 156 | 159 | 160 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 151 | | -. | -. | -. | - | - | + | + | + | + | + |
| 152 | | | -. | -. | -. | -. | + | + | + | + | + |
| 155 | | | | -. | -. | -. | + | + | + | + | + |
| 157 | | | | | -. | -. | + | + | + | + | + |
| 158 | | | | | | -. | + | + | + | + | + |
| 161 | | | | | | | + | + | + | + | + |
| 153 | | | | | | | | -. | -. | -. | -. |
| 154 | | | | | | | | | -. | -. | -. |
| 156 | | | | | | | | | | -. | -. |
| 159 | | | | | | | | | | | -. |
| 160 | | | | | | | | | | | |

body VIII are somewhat puzzling. The fact that one pairing produced clamp connections would indicate that both sexual phases were represented in the nine monospore cultures used. However, if this is true, there must exist some condition which causes a very low degree of compatibility between the two sexual phases. These results are similar to those reported by Kniep (10) for *Auricularia mesenterica*. He found a fruit body which showed clamp connections but mycelium grown from a mass of spores produced no clamps.

From the foregoing it will be noted that all fruit bodies, except number VIII, showed distinctly the presence of two sexual phases, and that all of these, except for six pairings in I, showed normal regular compatibility between the two sexual phases. Such results indicate that *A. Auricula-Judae* is "heterothallic" and typically bipolar.

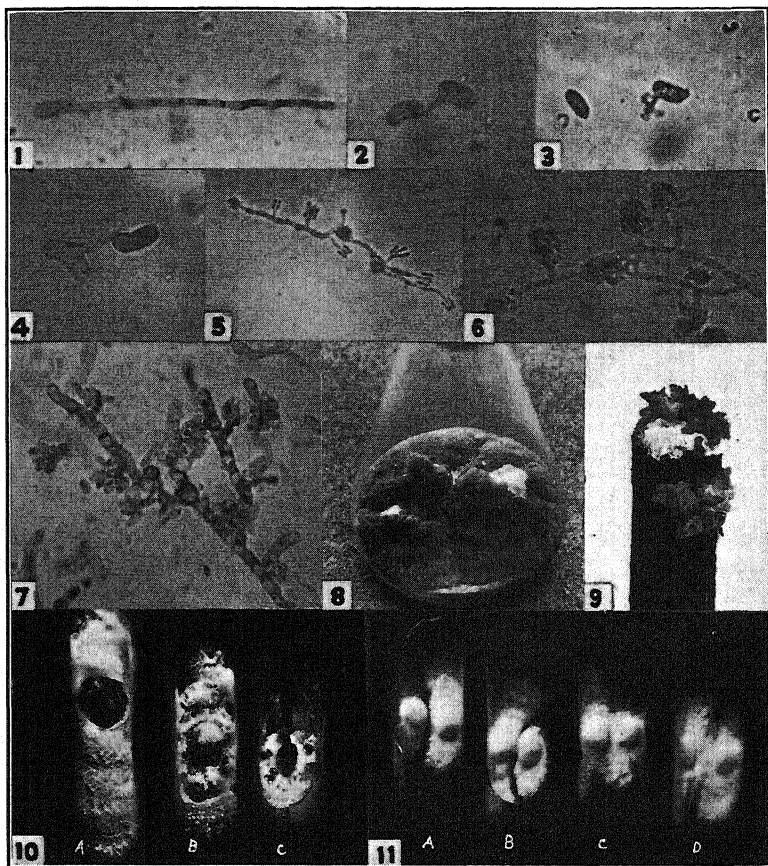


FIG. 3. *Auricularia* and *Exidia*.

In most cases when pairings were made between different fruit bodies, two monospore cultures from each sexual phase were chosen from each fruit body and mated with those of the other fruit bodies. In some cases where results were irregular more

cultures were used. In all tables the brackets connect the cultures of the same sexual phase. The results of these pairings fell into four different types. (1) Every pairing was compatible. This was the case in all combinations of fruit bodies III, IV, Va, VI and VII, and also of $Va \times Vb$ and $VII \times VIII$. The cross of $III \times IV$ is given as an example in Table 4. (2) When pairings were made between fruit body I and fruit bodies III, IV, VI and VII, all were incompatible. The results of the cross $I \times III$ are given as an example in Table 5. (3) In some of the crosses involving I and VIII some of the pairings were compatible while

TABLE 4

A. Auricula-Judae. RESULTS OF
PAIRINGS BETWEEN FRUIT
BODIES III AND IV

| | | III | | | | |
|----|----------------|----------------|-----|----------------|-----|-----|
| | | A ₁ | | a ₁ | | |
| | | | 101 | 105 | 104 | 112 |
| IV | A ₂ | 151 | + | + | + | + |
| | | 152 | + | + | + | + |
| | a ₂ | 153 | + | + | + | + |
| | | 154 | + | + | + | + |

TABLE 5

A. Auricula-Judae. RESULTS OF
PAIRINGS BETWEEN FRUIT
BODIES I AND III

| | | III | | | | |
|---|---|----------------|-----|----------------|-----|-----|
| | | A ₁ | | a ₁ | | |
| | | | 101 | 105 | 104 | 112 |
| I | A | 3 | — | — | — | — |
| | | 7 | — | — | — | — |
| | a | 4 | — | — | — | — |
| | | 6 | — | — | — | — |

others were incompatible. This was true of $I \times Va$ (Table 6), $I \times VIII$ (Table 7), $III \times VIII$ (Table 8) and $IV \times VIII$. In the last cross only one out of 20 pairings was compatible. In all these the compatible pairings were scattered and did not correspond to any certain combinations of sexual phases. (4) In the cross $III \times III F_1$, clamp connections were found in just half of the pairings and only in certain combinations of sexual phases, indicating that the two sexual phases of $III F_1$ were identical with those of III. In the first, second and third types the results show that no two sexual phases involved are identical. This implies the conception that within this species, several or many sexual phases exist, only two such phases being present in the same fruit body, and that only one pair of chromosomes is involved. This view

TABLE 6

A. Auricula-Judae. RESULTS OF PAIRINGS
BETWEEN FRUIT BODIES I AND Va

| | | A ₃ | | | | a ₃ | | | |
|---|----|----------------|-----|-----|-----|----------------|-----|-----|-----|
| | | 201 | 205 | 207 | 208 | 203 | 204 | 206 | 211 |
| A | 1 | — | — | — | — | — | — | — | — |
| | 3 | — | — | + | + | — | — | — | — |
| | 7 | — | — | — | — | — | — | + | — |
| | 18 | — | — | — | — | — | + | — | + |
| I | 4 | + | — | — | — | + | — | — | — |
| | 6 | — | — | — | + | + | + | — | — |
| | 8 | — | — | — | — | + | — | — | — |
| | 9 | — | — | — | — | — | — | — | — |

TABLE 7

A. Auricula-Judae. RESULTS OF
PAIRINGS BETWEEN FRUIT
BODIES I AND VIII
VIII

| | | 501 | 502 | 503 | 504 | 505 |
|---|---|-----|-----|-----|-----|-----|
| A | 3 | — | + | + | — | — |
| | 7 | + | + | + | + | + |
| I | 4 | + | + | + | + | + |
| | 6 | + | + | + | + | + |

TABLE 8

A. Auricula-Judae. RESULTS OF
PAIRINGS BETWEEN FRUIT
BODIES III AND VIII
VIII

| | | 501 | 502 | 503 | 504 | 505 |
|----------------|-----|-----|-----|-----|-----|-----|
| A ₁ | 101 | + | — | + | + | — |
| | 105 | + | — | + | + | — |
| III | 104 | + | — | + | + | — |
| | 112 | + | — | + | + | — |

supposes the presence of the compatibility factors as multiple allelomorphs.

A summary of all the pairings of monospore cultures is given in Table 9. The + sign indicates that all pairings were compatible, while the — sign indicates that all pairings were incompatible. The ± sign indicates that some of the pairings were compatible and others were incompatible.

In the tables the genetical designation of the sexual phases (A, a, A₁, a₁, etc.) is entirely arbitrary. The letters with subscripts

represent allelomorphs of A and a. Following Kniep, it is assumed that the presence of two identical compatibility factors results in incompatibility and that compatibility results (*i.e.* clamp connections are produced) when two somewhat different factors of the allelomorphic series are present. It is further assumed that incompatibility also results if there is too great a difference be-

TABLE 9
A. Auricula-Judae. SUMMARY OF RESULTS OF ALL PAIRINGS OF
MONOSPORE CULTURES

| | | I | | III | | III F ₁ | | IV | | Va | | Vb | | VI | | VII | | VIII |
|--------------------|----------------|---|---|----------------|----------------|--------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|------|
| | | A | a | A ₁ | a ₁ | A ₁ | a ₁ | A ₂ | a ₂ | A ₃ | a ₃ | A ₄ | a ₄ | A ₅ | a ₅ | A ₆ | a ₆ | |
| I | A | - | + | - | - | | | - | - | ± | ± | | | - | - | - | - | ± |
| | a | | - | - | - | | | - | - | ± | ± | | | - | - | - | - | + |
| III | A ₁ | | | - | + | - | + | + | + | + | + | | | + | + | + | + | ± |
| | a ₁ | | | | - | + | - | + | + | + | + | | | + | + | + | + | ± |
| III F ₁ | A ₁ | | | | | - | + | | | | | | | | | | | |
| | a ₁ | | | | | | - | | | | | | | | | | | |
| IV | A ₂ | | | | | | | - | + | + | + | | | + | + | + | + | - |
| | a ₂ | | | | | | | | - | + | + | | | + | + | + | + | ± |
| Va | A ₃ | | | | | | | | | - | + | + | + | + | + | + | + | |
| | a ₃ | | | | | | | | | | - | + | + | + | + | + | + | |
| Vb | A ₄ | | | | | | | | | | | - | + | | | | | |
| | a ₄ | | | | | | | | | | | | - | | | | | |
| VI | A ₅ | | | | | | | | | | | | | - | + | + | + | |
| | a ₅ | | | | | | | | | | | | | | - | + | + | |
| VII | A ₆ | | | | | | | | | | | | | | | - | + | + |
| | a ₆ | | | | | | | | | | | | | | | | - | + |
| VIII | | | | | | | | | | | | | | | | | | + |

tween the two factors. This latter assumption may serve as a partial explanation for the low degree of compatibility between two fruit bodies, but it also seems quite possible that some other factors or conditions are present which influence the compatibility between fruit bodies.

No special work was done with the phenomenon of aversion but it was observed in a number of pairings, especially of fruit body IV (Table 3). Of the 55 pairings three types were observed:

(1) 22 (one compatible pairing) showed space of aversion (FIG. 3: 11A and B); (2) two (both compatible) showed aversion in which the gap was partially filled with dicaryon mycelium (FIG. 3: 11D); (3) 31 (29 compatible pairings) showed even intermingling of the mycelia (FIG. 3: 11C). These results indicate that in this fruit body there was a rather close correlation between the presence of aversion and incompatibility of the pairings. Aversion in pairings of mycelia from other fruit bodies was observed only in a few cases and its presence showed no correlation with incompatibility.

The same method used in pairing monospore cultures of *A. Auricula-Judae* was followed for the other species.

E. GLANDULOSA

Monospore cultures from the same fruit body were paired as follows: 15 from I, nine from IIa, ten from IIb and ten from III. The results in every case indicated normal bipolarity. No irregular results were found. In the pairings between fruit bodies, four monospore cultures from each were used. The cross IIa \times IIb was repeated using eight cultures from IIa and all ten from IIb. A summary of all pairings is given in Table 10. The results

TABLE 10
E. glandulosa. SUMMARY OF RESULTS OF ALL
PAIRINGS OF MONOSPORE CULTURES

| | | I | | IIa | | IIb | | III | |
|-----|----------------|---|---|----------------|----------------|----------------|----------------|----------------|----------------|
| | | A | a | A ₁ | a ₁ | A ₂ | a ₂ | A ₃ | a ₃ |
| I | A | — | + | + | + | + | + | + | + |
| | a | | — | + | + | + | + | + | + |
| IIa | A ₁ | | | — | + | + | + | + | + |
| | a ₁ | | | | — | + | + | + | + |
| IIb | A ₂ | | | | | — | + | + | + |
| | a ₂ | | | | | | — | + | + |
| III | A ₃ | | | | | | | — | + |
| | a ₃ | | | | | | | | — |

show that no two of the sexual phases were identical. Thus, as in *A. Auricula-Judae*, the sexual phases are considered as being due to factors that exist as multiple allelomorphs. The genetical designations for each fruit body are given in Table 10.

When the pairings between fruit bodies IIa and IIb were examined, it was noticed that abundant clamp connections were present in some, while in others they were present in much smaller numbers. Preliminary experiments showed that the low numbers were limited to pairings between certain definite sexual phases, namely $A_1 \times A_2$ and $a_1 \times a_2$. To determine the quantitative differences in the number of clamp connections, pairings were made between all combinations of sexual phases, using three monospore cultures from each. Bits of two monocaryon mycelia were placed on malt agar plates at a distance of about 1 cm. apart and incubated at room temperature. In order to make the conditions uniform it was necessary to know the exact time at which the two mycelia came into contact. This was accomplished by placing sterilized halves of cover glasses into the agar in an upright position between the two mycelia. The mycelia were allowed to grow up against the cover glass which was then removed. At the end of 48 hours after the removal of the intervening cover glasses the pairings were examined at the line of contact between the mycelia using the oil immersion lens. A drop of aqueous safranin was usually added to make the hyphae more distinct. Areas were chosen in which the hyphae could be seen clearly and in which their number was about average, and counts were made of the clamp connections in the entire field, both on the surface and below the surface of the agar as far as the focus of the lens would reach. Ten counts were made from each pairing between two monocaryon mycelia. The averages of these counts are given in Table 11. Table 12 gives the averages for each combination of sexual phases.

Certain distinct differences in reactions are evident. $A_1 \times a_1$, $A_2 \times a_2$ and $A_2 \times a_1$ produced approximately the same number of clamp connections, averaging 13.6, 13.0 and 13.0 respectively. $A_1 \times A_2$ and $a_1 \times a_2$ showed a decidedly smaller number, averaging 6.4 and 5.5 respectively. The average of $A_1 \times a_2$ was intermediate, being 10.3. When analyzed statistically, significant differences were found between the following pairs of combinations:

$A_1 \times A_2$ and $A_1 \times a_2$, $A_1 \times A_2$ and $A_1 \times a_1$, $A_1 \times A_2$ and $a_1 \times A_2$, $A_1 \times A_2$ and $A_2 \times a_2$, $a_1 \times A_2$ and $a_1 \times a_2$, $A_1 \times a_2$ and $a_1 \times a_2$, and $A_1 \times a_2$ and $A_1 \times a_1$.

Attempts were made to determine the exact cause of the differences in the number of clamp connections. It was found that in actively growing mycelia the number of septa without clamp connections was small and no distinct difference was observed in any of the mycelia. It was also thought that a difference might exist in the rate of diploidization of one monocaryon mycelium by an-

TABLE 11

E. glandulosa. RESULTS OF CLAMP CONNECTION COUNTS IN PAIRINGS BETWEEN FRUIT BODIES IIa AND IIb

The numbers represent the average number of clamps per microscopic field.

| | | A_1 | | | a_1 | | | a_2 | | |
|-------|----|-------|------|------|-------|------|------|-------|------|------|
| | | 21 | 23 | 24 | 27 | 28 | 30 | 51 | 52 | 57 |
| A_2 | 50 | 5.5 | 5.1 | 7.5 | 11.8 | 13.1 | 13.1 | 13.9 | 14.3 | 12.4 |
| | 53 | 7.3 | 6.1 | 7.1 | 14.6 | 16.4 | 11.4 | 14.7 | 13.5 | 14.6 |
| | 55 | 4.8 | 7.9 | 6.1 | 11.3 | 12.6 | 13.1 | 12.7 | 12.0 | 8.8 |
| a_2 | 51 | 11.6 | 12.8 | 9.2 | 5.2 | 7.5 | 5.0 | | | |
| | 52 | 10.0 | 10.5 | 8.8 | 6.5 | 5.0 | 5.0 | | | |
| | 57 | 9.8 | 10.5 | 9.6 | 5.3 | 4.9 | 5.3 | | | |
| a_1 | 27 | 15.3 | 17.1 | 10.9 | | | | | | |
| | 28 | 11.9 | 13.2 | 12.2 | | | | | | |
| | 30 | 12.3 | 16.9 | 12.5 | | | | | | |

TABLE 12

E. glandulosa. SUMMARY OF RESULTS GIVEN IN TABLE 11

| | A_1 | a_1 | a_2 |
|-------|-------|-------|-------|
| A_2 | 6.4 | 13.0 | 13.0 |
| a_2 | 10.3 | 5.5 | |
| a_1 | 13.6 | | |

other. The method employed was similar to the one used by Bul-
ler (5). Bits of mycelium from cultures 28 and 30 were used to
diploidize sets of cultures 53, 55, 52 and 57. Conversely, bits of
mycelium cultures 53, 55, 52 and 57 were used to diploidize cul-
tures of 28 and 30. The cultures in each case were 13 days old.
At the end of seven days after diploidization, examination showed
the presence of clamp connections in every case at a distance of
1 cm. from the point of diploidization. This distance, however,
was short enough to be accounted for by the radial growth of the

dicaryon mycelia, which ranged from 12 to 16 mm. in the seven-day period. In three cases clamp connections were found at a distance of 2 cm. and in two cases at a distance of 3 cm. These results show that the rate of diploidization cannot serve as an explanation for the differences found in the number of clamp connections.

It seems possible that there may be a greater attraction between certain mycelia (if such an attraction exists at all) and as a result the union of mycelia may take place sooner than if a lesser attraction exists. Consequently, a greater number of clamp connections would be formed within the 48 hours that elapsed between the removal of the cover glass from between the mycelia and the counting of the clamp connections. This, however, is purely suppositional and is offered merely as a possible explanation for the differences found. As yet, no successful attempts have been made to demonstrate the presence of such an attraction between compatible mycelia.

E. RECISA

Monospore cultures from the same fruit body were paired as follows: 20 cultures from fruit body I, 10 from II and 10 from III. In all cases the results were very regular and showed the presence of two sexual phases. Four monospore cultures from each fruit body were used in the pairings between different fruit bodies. All pairings between members of any two sexual phases were compatible. A summary of the results of all pairings is given in Table 13. Thus, as in *A. Auricula-Judae* and in *E. glandulosa*, there are present in *E. recisa* a number of sexual phases which are thought to exist as multiple allelomorphs.

E. SACCHARINA

Two fruit bodies were selected from the only collection of this species and designated as Ia and Ib. Seven monospore cultures of Ia were paired in all combinations as were 16 cultures of Ib. The results were very regular, showing the presence of two sexual phases in each fruit body. Four monospore cultures of Ia were paired with four cultures of Ib and the results showed the pres-

TABLE 13
E. recisa. SUMMARY OF RESULTS OF ALL
 PAIRINGS OF MONOSPORE CULTURES

| | | I | | II | | III | |
|-----|----------------|---|---|----------------|----------------|----------------|----------------|
| | | A | a | A ₁ | a ₁ | A ₂ | a ₂ |
| I | A | — | + | + | + | + | + |
| | a | | — | + | + | + | + |
| II | A ₁ | | | — | + | + | + |
| | a ₁ | | | | — | + | + |
| III | A ₂ | | | | | — | + |
| | a ₂ | | | | | | — |

ence of clamp connections in every pairing. Again, as in *E. glandulosa*, complete compatibility was found to exist between two fruit bodies growing very near one another.

E. NUCLEATA

A few multispore cultures were obtained from one wild fruit body but owing to the very poor germination of the spores no monospore cultures were secured at this time. However, monospore cultures were later secured from fruit bodies produced in culture. These cultures grew very slowly and several of them either became contaminated or died out due to loss of vigor. Eleven cultures were paired in all combinations (with the exception of a few pairings) and the results are given in Table 14. The blanks in the table indicate no pairing because of the loss of cultures. Cultures 3, 14, 15, 17, 26 and 27 fell into one sexual phase and 12, 13 and 22 into a second sexual phase. All members of the first phase were compatible with all members of the second. Cultures 25 and 30, however, were exceptions to the normal polarity in their pairing reactions. These two cultures were incompatible with all the other monospore cultures and also with each other. It is not possible to tell from these results whether these groups represent three sexual phases of a quadripolar species, or whether *E. nucleata* is typically bipolar and that cultures

TABLE 14
E. nucleata. RESULTS OF PAIRING 11 MONOSPORE CULTURES
 \oplus = fertile fruit bodies.

| | 3 | 14 | 15 | 17 | 26 | 27 | 12 | 13 | 22 | 25 | 30 |
|----|---|----|----|----|----|----|----|----------|----------|----|----|
| 3 | | - | - | - | | - | + | \oplus | + | - | - |
| 14 | | | - | - | - | - | | \oplus | | - | - |
| 15 | | | | | - | - | + | \oplus | \oplus | - | - |
| 17 | | | | | - | - | + | + | \oplus | - | - |
| 26 | | | | | | - | + | \oplus | + | - | - |
| 27 | | | | | | | + | | \oplus | - | |
| 12 | | | | | | | | | - | - | - |
| 13 | | | | | | | | | - | - | - |
| 22 | | | | | | | | | | - | - |
| 25 | | | | | | | | | | | - |
| 30 | | | | | | | | | | | |

25 and 30 were merely irregular in their compatibility. The later view seems more probable. The \oplus sign indicates the production of fruit bodies with mature basidia and basidiospores.

Attempts were made to hybridize *E. recisa* with *E. glandulosa* and *E. saccharina* but all were unsuccessful.

DISCUSSION

The terms used by different authors in describing the sexuality of the Basidiomycetes vary to a certain extent. The term "sexes" has been applied by a number of investigators to the different groups into which the monospore cultures fall, based upon the production of clamp connections when the cultures from one fruit body are paired in all combinations.

Considering the fungi in general, the term "sexes" is most commonly used to distinguish two individuals, one of which acts as male and the other as female. This conception includes the passage of nuclei from only one individual (male) to the other (female). In many fungi, however, this is not the case. Buller (6) has shown that, in *Coprinus lagopus*, two compatible mono-

caryon mycelia may unite and there would follow an exchange of nuclei so that each mycelium becomes diploidized by the other. It seems reasonable to consider that in such fungi sexuality exists but with no distinction between sexes. For this reason the term "sexual phases," used by Bessey (2), is employed in this paper instead of "sexes" which is used by some authors.

Following Smith and Brodie (17) and Bessey (2), the terms "compatible" and "incompatible" are used throughout the present paper in the same sense that "fertile" and "sterile" are used by some other investigators. The term "compatible" is used to describe two monocaryon mycelia which unite, with subsequent production of dicaryon mycelium (indicated by the presence of clamp connections) and "incompatible" is used to describe two monocaryon mycelia which do not produce dicaryon mycelium.

The results obtained from pairing monospore cultures of the same fruit body of each species indicate that *A. Auricula-judae*, *E. glandulosa*, *E. recisa* and *E. saccharina* are typically bipolar. The pairing of monospore cultures of one fruit body of *E. nucleata* did not show typical bipolarity. Irregularities were found in pairings of monospore cultures of fruit bodies of I and VIII of *A. Auricula-Judae*. In I these were represented by constant incompatibility between certain monospore cultures of different sexual phases. Such irregularities or deviations from the normal polarity have also been reported by Kniep (10), Vandendries (21, 22), Brunswik (4) and Dickson (7) for various Hymenomycetes. As suggested by Dickson, there seem to be present some conditions or some additional factors which influence the compatibility of monospore cultures. Vandendries (22) considers that the tendency toward incompatibility is due to "une déficience des réalisateurs sexuels." Kniep (10) attributes such deviations to quantitative gene changes.

It has been observed in the present work that within the same species complete compatibility was found between three collections of *E. glandulosa*, three collections of *E. recisa* and between five of the seven collections of *A. Auricula-Judae* (III, IV, V, VI and VII). In addition to the pairings between fruit bodies of different collections, complete compatibility was found to exist between two fruit bodies of *A. Auricula-Judae* (Va and Vb), taken

from the same collection. This was also true for two fruit bodies of *E. saccharina* (Ia and Ib) growing on the same stick within 12 inches of each other, and for two fruit bodies of *E. glandulosa* (IIa and IIb) growing but two inches apart. Similar complete compatibility between the monocaryon mycelia of two or more fruit bodies have been reported by Kniep (10), Brunswik (4), Newton (13), Vandendries (18, 19, 20, 22), Hanna (8), Mounce (11) and Arnold (1) for various Hymenomycetes.

Complete incompatibility was found in *A. Auricula-Judae* when cultures of fruit body I were paired with cultures from fruit bodies III, IV, VI and VII. Partial compatibility existed between fruit bodies I and Va, I and VIII, III and VIII, and IV and VIII. Fruit bodies I and VIII were collected from coniferous hosts and had longer spores on the average than those of other fruit bodies, which were collected from deciduous hosts. It is suggested that the variation in spore length, or the difference in the hosts, or both, may be associated with genetic differences great enough to influence the compatibility of the monocaryon mycelia. Similar cases of complete or partial incompatibility between fruit bodies of the same species have been reported by Kniep (10), Brunswik (4), Vandendries (20) and Mounce (11). Kniep (10) states that such incompatibility may be due to too great a quantitative difference in the genes or to secondary factors.

Several different theories of sexuality in fungi have been advanced to explain the complete compatibility found to exist between different fruit bodies of the same species. Among them are the theory of sexual mutations, Hartman's (9) theory of relative sexuality and Kniep's theory of multiple allelomorphs. The theory of Kniep seems to be the best for interpreting the results of the present work.

Considering that the compatibility factors exist as multiple allelomorphs, the question arises whether certain pairs of factors will produce a stronger degree of compatibility than others. A probable answer to this question was found when all monospore cultures of *E. glandulosa* IIa were discovered to be compatible with all cultures of IIb and a greater number of clamp connections were found in certain combinations of sexual phases than in others. The assumption is made in these experiments that a greater num-

ber of clamp connections indicates a stronger degree of compatibility between the monospore cultures involved. The results shown in Table 12 would then indicate a much stronger degree of compatibility between A_1 and a_1 , A_2 and a_2 , A_1 and a_2 , and A_2 and a_1 , than exists between A_1 and A_2 , and a_1 and a_2 . If the numbers of clamp connections can be considered, in this case, as representing the approximate quantitative differences between pairs of allelomorphs, it is found that the factors a_1 and a_2 are the most similar, with A_1 and A_2 only slightly less similar. The greatest differences are between A_1 and a_1 , A_2 and a_2 , and A_2 and a_1 .

Diploidization rates were found to be about the same in pairings of $a_1 \times A_2$ and $a_1 \times a_2$. The variations that did occur were not sufficient to explain the differences found in the number of clamp connections. It is suggested that there may be a greater attraction between certain monocaryon mycelia than others, but as yet, no such attraction has been demonstrated.

POSTSCRIPT

Since the manuscript was sent to press a collection of *A. Auricula-Judae* (number IX) was received from Dr. F. A. Wolf of Durham, N. C. Monospore cultures from one fruit body showed typical bipolarity. When these cultures were paired with those from fruit bodies of other collections it was found that fruit body IX was completely compatible with fruit bodies III, IV and Va, partially compatible with VIII and completely incompatible with I.

Four additional monospore cultures from fruit body VIII were paired with the nine already obtained. Three of these pairings produced clamp connections.

DEPARTMENT OF BOTANY,
MICHIGAN STATE COLLEGE,
EAST LANSING, MICHIGAN

LITERATURE CITED

1. Arnold, Jean D. A comparative study of certain species of *Marasmius* and *Collybia* in culture. *Mycologia* 27: 388-417. pl. 35, 36. 1935.
2. Bessey, Ernst A. A text-book of mycology. 495 pp. 139 fig. P. Blakiston's Son and Co., Philadelphia. 1935.
3. Bose, S. R. Sexuality of *Polyporus ostreiformis* and *Polystictus hirsutus*. *La Cellule* 42: 249-266. 1 pl. 1933.

4. **Brunswik, H.** Untersuchungen über die Geschlechts- und Kernverhältnisse der Hymenomycetengattung *Coprinus*. Botanische Abhandlungen herausgegeben von Dr. K. Goebel 1: 1-152. fig. 1-3. 1924.
5. **Buller, A. H. Reginald.** The biological significance of conjugate nuclei in *Coprinus lagopus* and other Hymenomycetes. Nature 126: 686-689. fig. 1-7. 1930.
6. —. Researches on fungi. Longmans, Green and Company. London and New York. Vol. IV. 329 pp. 4 pl., 149 fig. 1931.
7. **Dickson, H.** Studies on *Coprinus sphaerosporus*. I. The pairing behavior and the characteristics of various haploid and diploid strains. Ann. Bot. 48: 527-547. pl. 11. 1934.
8. **Hanna, W. F.** The problem of sex in *Coprinus lagopus*. Ann. Bot. 39: 431-457. 1925.
9. **Hartmann, M.** Relative Sexualität und ihre Bedeutung für eine allgemeine Sexualitäts- und eine allgemeine Befruchtstheorie. Naturwiss. 19: 8-19, 31-37. 1931. Cited by Bose (3).
10. **Kniep, Hans.** Die Sexualität der niederen Pflanzen. 544 pp. 221 fig. Gustav Fischer. Jena. 1928.
11. **Mounce, Irene.** The biology of *Fomes pinicola* (Sw.) Cooke. Canada Dept. Agr. Bull. 111. New Series. 75 pp. pl. 1-10. 1929.
12. **Neuhoff, W.** Zytologie und systematische Stellung der Auriculariaceen und Tremellaceen. Bot. Archiv 8: 250-297. pl. 1-4, fig. 1-7. 1924.
13. **Newton, Dorothy E.** Bisexuality of individual strains of *Coprinus rostrupianus*. Ann. Bot. 40: 105-128. pl. 6, fig. 1-17. 1926.
14. **Rogers, Donald P.** A cytological study of *Tulesnella*. Bot. Gaz. 94: 86-105. fig. 1-79. 1932.
15. —. Basidial proliferation through clamp formation in a new *Sebacina*. Mycologia 28: 347-362. fig. 1-34. 1936.
16. **Shear, C. L. & B. O. Dodge.** The life history of *Pilacre faginea* (Fr.) B. & R. Jour. Agr. Res. 30: 407-417. pl. 1-2. 1925.
17. **Smith, A. H. & H. J. Brodie.** Cultural characters and pairing reactions of monosporous mycelia and development of the fruit body of *Pholiota (Flammula) polychroa*. Bot. Gaz. 96: 533-546. 30 fig. 1935.
18. **Vandendries, René.** Nouvelle recherches sur la sexualité des Basidiomycètes. Bull. Soc. Bot. Belgique 62: 133-136. 1924.
19. —. Contribution nouvelle a l'étude de la sexualité des Basidiomycètes. La Cellule 35: 129-157. pl. 1-2, fig. 1-4. 1925.
20. —. Le comportement sexuel du *Coprinus micaceus* dans ses rapports la dispersion de l'espèce. Bull. Soc. Bot. Belg. 60: 62-65. 1927.
21. —. La bipolarité sexuelle chez *Coprinus disseminatus* Pers. Bull. Soc. Bot. Belg. 62: 133-136. 1930.
22. —. Nouvelle investigations dans le domaine sexuel des Hyménomycetes. Bull. Soc. Fr. 49: 130-165. 7 fig. 1933.
23. **Whelden, Roy M.** Cytological studies in the Tremellaceae. I. *Tremella*. Mycologia 26: 415-435. pl. 47-49. 1934.

24. —. —. II. *Exidia*. Mycologia 27: 41–57. pl. 8–11. 1935.
25. —. —. III. *Sebacina*. Mycologia 27: 503–520. fig. 1–3. 1935.
26. —. Observations on the cytology of *Sebacina globospora* n. sp. Rhodora 37: 121–127. 1 text fig., pl. 331. 1935.

EXPLANATION OF FIGURES

Fig. 1: 1–8, *A. Auricula-Judae*. 1, basidiospores; 2, *A*, basidiospore germinating in water, *B*, oidia produced by spores in water; 3, 4, basidiospores germinating on agar; 5, germinating oidia; 6, monocaryon hypha bearing oidia; 7, dicaryon hypha showing clamp connections; 8, basidium from fruit body in culture. 9–17, *E. glandulosa*. 9, *A*, *B*, basidiospores germinating in water, *C*, oidia produced by them; 10, basidiospores; 11, basidiospore producing secondary spore; 12, 13, basidiospores germinating on agar; 14, dicaryon hypha showing clamp connections; 15, germinating oidia; 16, two-celled basidium produced by monocaryon mycelium; 17, union of two young hyphae, arrows point toward germinating spores.

Fig. 2: 1–5, *E. recisa*. 1, basidiospores; 2, basidiospore germinating on agar; 3, same as 2 but producing oidia; 4, four-celled basidium produced on dicaryon mycelium; 5, dicaryon hypha. 6–11, *E. saccharina*. 6, dicaryon hyphae with oidia; 7, binucleate oidia from dicaryon mycelium; 8, uninucleate oidia from monocaryon mycelium; 9, monocaryon hypha bearing oidia; 10, union of young hyphae from two basidiospores; 11, germinating binucleate oidium. 12–15, *E. nucleata*. 12, germinating oidia; 13, dicaryon hypha; 14, 15, four-celled basidia with septate epibasidia from fruit body in culture.

Fig. 3: 1–3, germination of basidiospores of *E. nucleata*, $\times 750$; 1, by a long germ tube; 2, by secondary spore; 3, by oidia. 4, *A. Auricula-Judae*, production of secondary spore, $\times 750$. 5, *E. saccharina*, germinating basidiospore and oidia borne on germ tube, $\times 400$. 6, *E. nucleata*, monocaryon hyphae bearing oidia, $\times 750$. 7, *E. recisa*, germinating oidia and mycelium produced by them, $\times 750$. 8, 9, fruit bodies of *A. Auricula-Judae*, $\times \frac{4}{5}$; 8, on agar, 9, on basswood stick. 10, *E. recisa*, gelatinous bodies in culture, *A*, dicaryon, *B*, *C*, monocaryon, $\times \frac{4}{5}$. 11, *A. Auricula-Judae*, pairings of monospore cultures of IV, *A*, aversion 155×157 , *B*, aversion 157×161 , *C*, even union of mycelia 157×160 , *D*, aversion with gap filled with dicaryon mycelium 154×157 , $\times \frac{7}{8}$.

NOTES AND BRIEF ARTICLES

A mimeographed program of the first Atlantic City meeting was mailed to the members of the Society in December 1932. Programs for subsequent meetings were printed. The Historian of the Society wishes to obtain a copy of this mimeographed program for preservation and binding as a part of the archives of the Society. He requests that any member who has preserved the program forward it to him for this purpose. He would also emphasize the desirability of members submitting photographs taken on the occasion of summer forays. It is hoped that in a few years the accumulation of such materials will provide an interesting exhibit which can be shown at one of the winter meetings.—H. M. FITZPATRICK.

A bumper crop of fleshy fungi appeared in central Florida the past summer, which kept the writer very busy collecting, describing, and testing various novelties; and teaching amateur mycophagists. *Lepiota Morgani*, for example, proved to be decidedly poisonous, though scarcely fatal. A thousand sporophores of this handsome plant appeared at once in a pasture and six of them were eaten at a meal. Among the boletes only one mildly poisonous species was found, *Boletus luridus*, but at least four were so decidedly bitter when cooked that not even a dog would eat them. A dozen new species of boletes were collected, described, and placed in the herbarium of the University of Florida. One of these, a beautiful golden species, was so abundant that a group of women picked four bushels of it in a single day for drying, canning, and pickling. *Boletus edulis* and *B. bicolor* were also very abundant. It would pay the towns of northern and central Florida to establish municipal mushroom markets with experts in charge to examine the specimens brought in before they were offered for sale. Mushrooms cannot be cultivated in Florida, but tons of delicious wild ones are going to waste in the state every year.—W. A. MURRILL.

NOTICES

The headquarters of the Mycological Society of America at the Indianapolis meetings of the A. A. A. S., Dec. 27, 1937 to Jan. 1, 1938, will be at the Washington Hotel, Washington Street, about four blocks north of the Union Station, and two blocks east of the Claypool and Lincoln which have been designated jointly as general headquarters of the A. A. A. S. The rates for the rooms, all of which are with bath, are \$2.25 to \$4.00 for a single room and \$3.75 to \$5.50 for double room.

As soon as possible after October 1st, blanks for the nomination of officers, and for application for place on the program, will be sent to members. It is hoped that these blanks will be returned properly filled at the earliest moment possible. It is also brought to your attention that by vote of the Council no person who is not a member of the Mycological Society may present a paper at the Society's meetings. It is therefore suggested that those members who have students that may wish to give papers, urge an immediate application for membership.



MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOL. XXIX NOVEMBER–DECEMBER, 1937

No. 6

THE CONIDIAL STAGE OF PEZIZA PUSTULATA

B. O. DODGE

(WITH 1 FIGURE)

Heat treatment which is so effective in inducing germination of ascospores of some species has been found indispensable in connection with genetic work with species of *Neurospora*, *Gelasinospora* and certain other forms. While the method is very effective in growing *Ascobolus carbonarius*, it is of practically no value to induce germination of spores of *Ascobolus magnificus*. It is very desirable that a method be discovered for germinating the spores of this species as well as those of other Ascomycetes where it has been reported that the primary ascus nucleus is tetraploid, while the nuclei of the vegetative hyphae are haploid. If this can be supported genetically it will settle once for all the controversy over double fertilization in the Ascomycetes. *Ascobolus magnificus* varies sufficiently to be adaptable for genetic work if the eight spores of an ascus could be made to germinate.

It is now twenty-five years since the writer published that note on "Artificial cultures of *Ascobolus* and *Aleuria*" (*Mycologia* 4: 218–222. 1912). Heat treatment was found to be effective in bringing about germination of the ascospores of the form reported as *Aleuria umbrina*. Fruiting bodies for that work had been found in the first weeks of June of that year on a spot where

[*MYCOLOGIA* for September–October (29: 557–650) was issued October 1, 1937.]

some wood had been previously burned in a shady section of The New York Botanical Garden.

Pure cultures of the fungus on heated soil extract agar always showed a conidial stage of the *Oedocephalum* type but, as was customary in those days, it was not considered "of much importance" and was not mentioned in the note. Taxonomists to-day, however, are giving more attention to the asexual or conidial stages of the Ascomycetes. It is obvious that every known characteristic morphological feature should be included in formal descriptions. Modern mycologists know that there are many species in which the conidial stage is of as much value in distinguishing genera and species as are the ascocarpic structures themselves. We are accustomed to the thought that the so-called sexual stage is the only important feature, because the ascocarpic structures are all diploid and sporophytic, when as a matter of fact, as it is accepted by every one for *Neurospora*, all of the ascocarpic tissues except the young asci themselves may very well be haploid and therefore "gametophytic." The presence of two or more distinct and haploid nuclei in a cell does not make the cell diploid or polyploid.

I have frequently spoken to Dr. Seaver about "*Aleuria umbrina*," regretting that mention of the conidial stage had not been made at the time. About June 10 of this year he brought to the laboratory a number of fine ascocarps of this species which is now regarded as a synonym of *Peziza pustulata*. He had collected them on a spot where a brush pile had been burned previously. This was not far from where the same species had been found in 1912. It is well illustrated by Seaver, in plate 29, North American Cup-Fungi, 1928. Ascospores from these fruiting bodies were sowed on plates of corn-meal agar and heated at 58° C. for one hour. Practically all of the ascospores germinated (FIG. 1, *i*). On the second day characteristic conidiophores bearing heads of conidia developed from the surface hyphae. The conidiophores (FIG. 1, *a*) are usually about 150–350 μ long, 3 or 4 celled, and end in an *Oedocephalum* head which varies greatly in shape and size—narrow clavate, oval to spherical, 12–20 \times 20–40 μ . Conidiophores may be much longer, sometimes even 1200 μ long with 10 or 15 cells.

The conidia are only very slightly colored and probably would be described as hyaline with a slightly roughened or warted surface, elliptical, $2.5-3 \times 6-9 \mu$ (FIG. 1, *b*, *g*). Some are larger, $4 \times 12 \mu$. The point where the conidium was originally attached

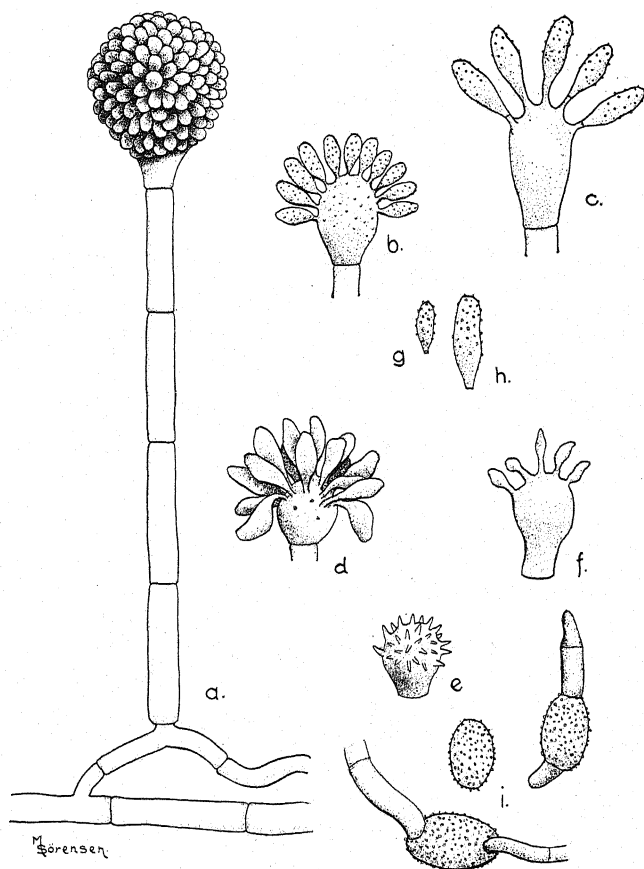


FIG. 1. *a*, conidiophore and *Oedocephalum* head of conidia of *Peziza pustulata* (*Aleuria umbrina*); *b*, similar head with many spores dislodged; *c*, small head of larger type of conidia (there were originally ten conidia on this head, the other five not shown); *d*, a rather abnormal type of conidial head; *e*, head showing sterigmata after conidia of the larger type have been dislodged; *f*, young conidiophore head; *g* and *h*, comparative sizes of the smaller and larger types of conidia; *i*, ascospores two of which are germinating after being given the heat treatment. The smaller types of conidia do not germinate even with the heat treatment and, therefore, according to some persons must be spermatia!

usually shows as a little papilla on the conidiophore head, and as a little knob on the lower end of the conidium.

Brefeld (Unters. Gesamtmt. Myk. 10: *pl. 13, fig. 19, 20, 24-26*) shows very similar conidial stages for *Peziza vesiculosa* and *P. cerea*. Although he undoubtedly had the best technique known at that time for culturing fungi, one is not always certain that his cultures were pure, and that forms which he often found associated together belong to the same species. For example, he describes a conidial form of *Sphaerulina intermixta*. One can readily prove that no such stage of this fungus develops in single ascospore cultures. The identity of *Peziza cerea*, according to Seaver, is not very well established. Having proved conclusively, however, that *Peziza pustulata* does have a characteristic conidial stage, there is less objection against assuming that *P. vesiculosa* and *P. cerea* develop somewhat similar conidial stages as described by Brefeld.

One of the sketches made, when the note on *Aleuria* was being prepared in 1912, shows a small head with a few very large conidia attached on rather long thick sterigmata as shown in fig. 1, *c*, which is a copy of the old drawing. There were only ten conidia on this head. On examination of our new cultures we found arising from the surface hyphae rather thick stalks slightly enlarged at the tip-ends. These heads were bearing the same type of large conidia (FIG. 1, *h*). These conidia are also rather distinctly warted, especially at the upper end. The conidiophores may be seven or eight cells in length. The attachment point shows on the conidium as a little socket and the sterigmata that remain on the head are much longer (FIG. 1, *e*). One can tell which heads originally bore the large conidia by the long sterigmata which remain. Occasionally intermediate types develop so that it may be that these differences in size have little significance. Figure 1, *d*, shows a head of a rather abnormal type. As to the functions of the two extreme types of conidia described, we are not ready to say at present. On several occasions we sowed thousands of the small conidia on corn meal agar, on bean agar and on heated soil decoction agar plates. Only one conidium which looked as though it might be germinating was found even after several days in any trial. This was transferred to another plate but it failed

to develop a mycelium. It is strange that the smaller conidia which are developed in such large numbers do not germinate. They are rather too large to be looked upon as spermatia. Since they do not germinate they must be "male," however! Only a few of the large type of conidia were available for germination studies. We succeeded in obtaining a normal mycelium from the only one which germinated. Plates on which both types of conidia were sowed were given the heat treatment without positive results. Plates upon which ascospores had been sowed at the same time showed practically 100 per cent germination after the heat treatment.

In our earlier experiments with this species we obtained solid masses of tissue which may have been the beginnings of ascocarps. The fruiting bodies of this species are of considerable size and one would not expect to obtain full development in petri dish cultures. Nothing is known regarding the sexual nature of the species whether it is heterothallic or not. At least, if one uses the heat treatment to obtain germination, we have a way of obtaining single spore cultures. It remains to find conditions for developing ascocarps under controlled conditions.

THE NEW YORK BOTANICAL GARDEN

NEW VENEZUELAN FUNGI IMPERFECTI

DAVID H. LINDER¹

(WITH 6 FIGURES)

The specimens described below were communicated to the writer by Professor H. H. Whetzel of Cornell University. They represent odds and ends of interesting Fungi Imperfecti that had not been included in Chardon and Toro's account of the Mycological Exploration of Venezuela, Monographs of the University of Puerto Rico, Ser. B (2): 9-353. *pl.* 1-33. 1934.

The type specimens of the new species described below have been deposited in the Farlow Herbarium, Harvard University, and in the Herbarium of the Department of Plant Pathology, Cornell University. For the privilege of studying and describing these species, the writer wishes to express his thanks to Professor Whetzel.

Cercosporella Hurae Linder & Whetzel, sp. nov. (FIG. A, B.)

Maculae usque 7 mm. diametro, orbiculatae vel irregulariter orbiculatae vel confluentae majores, centro "Chamois,"² margine atro-brunneae vel fere atrae, color in contexto hospitis diffusus; conidiophoris hypophyllis ex stromatibus laete coloratis, pseudoparenchymatis supra stomatibus hospitis oriundis, hyalinis, usque 150 μ longis, 4.5-6 μ diametro, isodiametricis vel sursum versus leniter fastigatis, septatis, non ad septa constrictis, unilateraliter vel alternis ramosis, ramis acute adscendentibus; conidiis acrogenis, hyalinis, cylindraceis, rectis, extremis abrupte rotundatis, (69)-75-100 \times 5-6 μ , multiseptatis, septis obscuris.

In foliis *Hurae crepitantis* L., Venezuela.

Spots up to 7 mm. in diameter, round or somewhat irregular, larger and more irregular by confluence, "Chamois" in center, bordered by a dark-brown or almost black margin, the color diffusing into the surrounding host tissue making it appear scorched; conidiophores hypophyllous, arising from a slightly colored pseudoparenchymatous stromatic base formed over the stoma of the host,

¹ Contribution from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University, No. 152.

² Ridgeway, R. Color Standards and Color Nomenclature, Washington, D. C., 1913, is cited when color names are given in quotation marks.

hyaline, up to $150\ \mu$ long, $4.5\text{--}6\ \mu$ in diameter at the base, slightly tapering upwards or isodiametric, septate, not constricted at the septa, unilaterally or alternately sympodially branched, the branches sharply ascending; conidia acrogenous, hyaline, many septate, the septa indistinct, cylindrical, straight, abruptly rounded at the ends, $(69)\text{--}75\text{--}100 \times 5\text{--}6\ \mu$.

On leaves of *Hura crepitans* L., east shore of Valencia Lake, 420 m. elev., Aragua, Venezuela, June 28, 1932, C. E. Chardon, Mycological Survey of Venezuela, 363.

Of the species of *Cercospora* that have been reported as occurring on Euphorbiaceous hosts, *C. Crotonis*, P. Henn. and *C. peronosporoides* Speg. appear from the descriptions to resemble this one most closely. However, *C. Crotonis* produces conidiophores which are said to measure $40\text{--}80 \times 5\ \mu$, and conidia that are $20\text{--}40 \times 3.5\text{--}5\ \mu$, while *C. peronosporoides* forms conidiophores that are $10\text{--}25 \times 5\text{--}6\ \mu$ and conidia that are $10\text{--}60 \times 5\text{--}7\ \mu$.

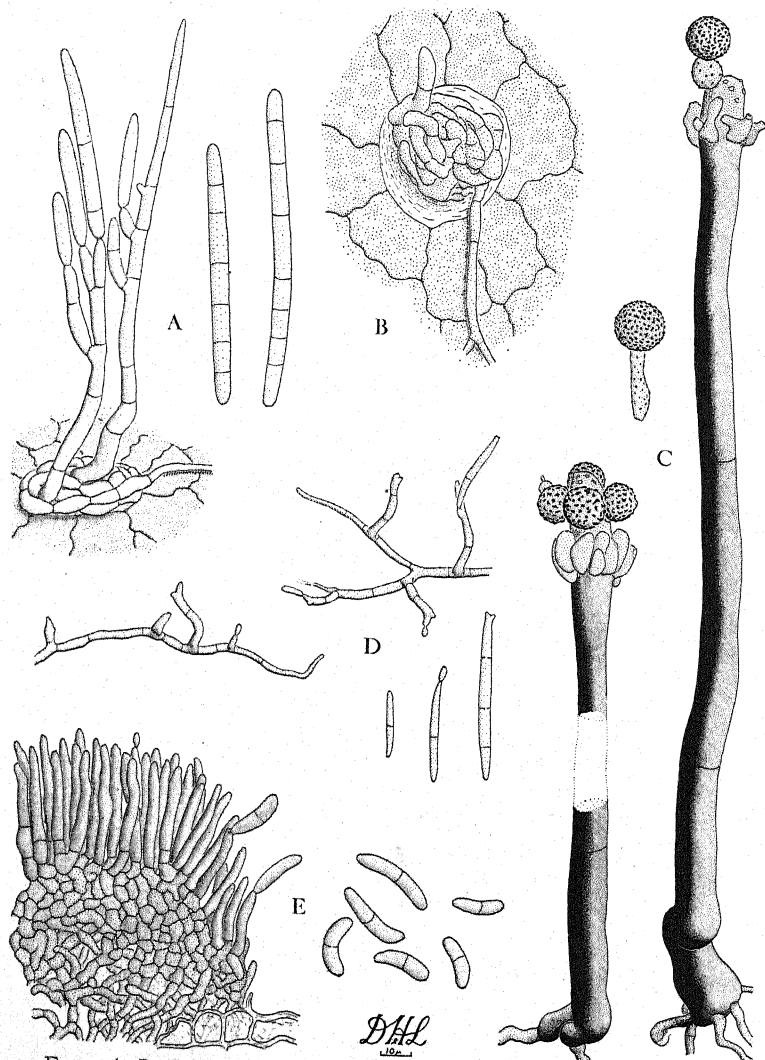
Periconia Toroi Linder, sp. nov. (FIG. C.)

Maculae irregulares, usque 10 mm. diametro, cinereae, translucetes, margine atro-brunneae; myceliis sterilibus gracilis, ramosis, septatis, intramatrix; conidiophoris simplicibus, atro-fuscis vel fere atris, ad apicem subfuscis, 1-3-septatis, usque $330\ \mu$ longis, infra $12\text{--}13.5\ \mu$, supra $10.5\text{--}12.5\ \mu$ diametro, ad basem nonnihil abrupte bulbose inflatis, cellula terminali sub apice verticillo unico cellularum sporogenarum primariarum cincta; cellulis sporogenis primariis irregulariter ellipsoideis vel elongato-ellipsoideis, simplicibus vel furcatis, inconspicuiter et sparse verruculosi, brunnei, non caducis, $9\text{--}15 \times 6\text{--}7.5\ \mu$; cellulis sporogenis secundariis sessilibus, caducis, ad regionem apicalem dilute coloratam conidiophoris vel ad cellulas sporogenas primarias gestis, ovoideis, elongato-ellipsoideis vel irregulariter clavulatis, dilute coloratis, sparse verruculosi, $9\text{--}15 \times 5\text{--}7.5\ \mu$; conidiis globosis, $15\text{--}16.5\text{--}(20)\ \mu$ diametro, conspicuiter et dense verruculosi, brunnei.

In foliis *Machaerii Moritziani* Benth., Venezuela.

Spots irregular, up to 10 mm. in diameter, cinereous, translucent, bordered by dark-brown margins: sterile mycelium slender, branched, septate, intramatrix: conidiophores simple, dark-brown to almost black, somewhat lighter colored near the apex and above the primary sporogenous cells, 1-3-septate, up to $330\ \mu$ long, $12\text{--}13.5\ \mu$ in diameter near the base, $10.5\text{--}12.5\ \mu$ above, the base often abruptly inflated into a bulbous swelling, the apical cell somewhat clavate-inflated; the primary sporogenous cells forming a whorl below the apex of the conidiophore, simple or branched, inconspicuously verruculose, not deciduous, $9\text{--}15 \times 6\text{--}7.5\ \mu$; the second-

dary sporogenous cells produced on the primary sporogenous cells or sessile on the apical region of the conidiophore above the



FIGS. A, B, *Cercospora Hurae*; C, *Periconia Toroi*; D, *Ramularia Malvastri*; E, *Pucciniopsis Lonchocarpi*.

whorl of primary sporogenous cells, light colored, sparsely and inconspicuously verruculose, irregular in shape, ovoid, elongate ellipsoid, or irregularly clavulate: conidia deeply colored, con-

spicuously and densely verrucose, globose, 15–16.5–(20) μ in diameter, in chains.

On leaves of *Machaerium Moritzianum* Benth., Hills Petare, Santa Lucia road, 1200–1250 m. elev., Miranda, Venezuela, July 8, 1932, Chardon & Toro, Mycological Survey of Venezuela, 440.

The writer takes great pleasure in dedicating this species to Professor Raphael A. Toro of the University of Puerto Rico in recognition of his interest in tropical fungi and of his enthusiasm as a collector.

This species is very similar to *P. pycnospora* Fres. and to *Pachytrichum Guazumae* Syd. (Ann. Myc. 23: 421–422. fig. 14. 1925) but from these two it may readily be separated by the fact that the terminal cell is much longer than wide and is slightly clavate inflated, whereas in the other two species the terminal cell is but slightly longer than wide, and is somewhat bulbous inflated. Although Sydow (*l.c.*) states that the conidiophores arise from a stromatic base, the morphology of the fruiting structure is such that it cannot well be distinguished from that of the genus *Periconia*. Therefore it is proposed here to make the new combination **Periconia Guazumae** (Syd.) Linder.

In order to bring out the differences between *P. Toroi* and other rough globose spored species of the genus, the following key has been constructed, for the most part based on the literature, but where possible amplified by a comparison of species in the von Hoehnel collection.

1. Spores less than 10 μ in diameter.....2.
1. Spores 10 μ or more in diameter.....4.
2. Spores 2 μ diam.; conidiophores 100 \times 2.5 μ , rarely septate, densely gregarious.....*P. Langloisii* Earle.
2. Spores 5–8 μ diam., minutely echinulate or roughened.....3.
3. Conidiophores 150–300 \times 14 μ (base), simple.....*P. Commonsii* Earle.
P. byssoides Pers.*
3. Conidiophores up to 500 μ in length, often somewhat branched at the apex; spores 6–8 μ diam., minutely roughened.....*P. nigriceps* Peck.
4. Spores minutely echinulate or muriculate.....5.
4. Spores verrucose or verruculose.....6.

* According to Earle (N. Y. Bot. Gard. Bull. 2: 332. 1902.) this is the same as *P. pycnospora* Fres. although Lindau (Rabenhorst, Krypt. Fl. 18: 613. 1906) states that the spores of *P. byssoides* are 5–7 μ diam., whereas those of *P. pycnospora* are 12–17 μ in diameter.

5. Spores $10-14\ \mu$ diam.; conidiophores $400-500 \times 14\ \mu$, 2-4-septate
P. epiphylla (Sw.) Earle.
5. Spores $16-18\ \mu$ diam., spines $0.5\ \mu$ long; conidiophores $200-300\ \mu$ long,
septate, curved-circinate above.....*P. circinata* (Mang.) Sacc.
6. Conidiophores $800-900 \times 17\ \mu$, 2-3-septate; spores $13\ \mu$ diam.
P. Coffae Zimm.
6. Conidiophores shorter.....7.
7. Conidiophores $18\ \mu$ diam. at base, $150-300\ \mu$ long, 1-2-septate (ob-
scurely); spores $16-18\ \mu$ diam.....*P. Palmeri* Earle.
7. Conidiophores of lesser diameter, or if as large then the spores are
smaller (see *P. Citharexyl*).....8.
8. Conidiophores $15-20\ \mu$ diam., $120-300\ \mu$ long; conidia $10-14\ \mu$ diam.,
granulose-verrucose.....*P. Citharexyl* Henn.
8. Conidiophores $10-16-(18)\ \mu$ diam., $100-400\ \mu$ long.....9.
9. Apical cell of conidiophore much longer than wide, the conidiophore up
to $350\ \mu$ long, $12-13.5\ \mu$ diam. near base, 1-3 septate; spores $15-16.5-$
 $(20)\ \mu$ diam., coarsely verrucose.....*P. Toroi* Linder.
9. Apical cell only slightly longer than wide, somewhat bulbous inflated..10.
10. Conidiophores solitary or scattered, not arising from a stromatic base,
 $200-300 \times 10-14-(18)\ \mu$, 1-several-septate; conidia $12-17\ \mu$ diam.,
finely verruculose.....*P. pycnosporous* Fres.
10. Conidiophores aggregated, arising from a stromatic base, $120-250$
 $\times 10-16\ \mu$, 1-3-septate; spores $7-18\ \mu$ diam., verruculose
P. Guazumae (Syd.) Linder.

Pucciniopsis Lonchocarpi Linder, sp. nov. (FIG. E.)

Maculae parvae, plerumque 1 mm. diametro minores, vel confluentes majores, supro ochraceo-cinereae, infra brunneae vel atro-brunneae; conidiophoris ex stromatibus pseudoparenchymatis, dilute fuscis, $20-60\ \mu$ crassis, $150-200\ \mu$ diametro vel confluendis amplioribus oriundis, fuscis vel ad apices dilute fuscis, minute et inconspicuiter verruculosi, 0-1-septatis, usque $30 \times 4.5\ \mu$, leniter ad apices rotundatis truncatisque fastigatis; conidiis 1-septatis, curvatis, nonnihil undulatis vel raro rectis, minute verruculosi, subhyalinis vel dilute fuscis, $18-30 \times 5-6\ \mu$, leniter ad basim truncatum et ad apicem abrupte vel acute rotundatum fastigatis.

In foliis *Lonchocarpi* sp., Venezuela.

Spots small, usually less than 1 mm. in diameter, but may be larger by confluence, yellowish or ochraceous cinerous above, dark-brown below: conidiophores hypogenous, arising on a colored pseudoparenchymatous stromatic base, up to $20-60\ \mu$ thick and up to 150 or $200\ \mu$ wide, wider by confluence: conidiophores densely aggregated into a hymenium-like layer, more deeply colored than the stromatic tissue, very minutely verruculose, 0-1-septate, up to $30 \times 4.5\ \mu$, slightly tapering to a rounded, truncate apex: conidia 1-septate, curved, undulate or rarely straight, minutely verruculose, subhyaline to dilute fuscous, $18-30 \times 5-6\ \mu$, slightly

tapering towards the truncate base and towards the abruptly or acutely rounded apex.

On *Lonchocarpus* sp., Hills Petare, Santa Lucia road, 1200–1250 m. elev., Miranda, Venezuela, July 8, 1932, Chardon & Toro, Mycological Survey of Venezuela, 432.

The morphology and dimensions of the conidiophores and conidia segregate this species from those previously described. *Pucciniopsis Caricae* (Speg.) Earle produces conidiophores that measure $40\text{--}50 \times 7\text{--}8 \mu$ and are non-septate, and conidia that are $18\text{--}20 \times 8\text{--}10 \mu$; *P. Anacardii* Sydow produces 1–3 celled conidiophores that are $12\text{--}25 \times 4\text{--}6 \mu$, and conidia that are $22\text{--}35 \times 9\text{--}12 \mu$; *P. caffra* Wakefield produces non-septate conidiophores, $10\text{--}15 \times 4\text{--}5 \mu$, which bear conidia $18\text{--}20\text{--}(24) \times 8\text{--}10 \mu$; and *P. quercina* Wakefield produces 4–5-septate conidiophores that are simple or short-furcate apically and $7\text{--}8\text{--}(9) \mu$ in diameter, while the conidia are $18\text{--}22.5 \times 12\text{--}14 \mu$.

Ramularia Malvastri Linder, sp. nov. (FIG. D.)

Maculae indistinctae, supra "Tawny," infra "Cream Color" vel "Cream Buff," usque 5 mm. diametro, orbiculatis vel angulatis, interdum confluentes; myceliis sterilibus externis in superficie inferiore foliae hospitis vel intra hospitem, hyalinis, septatis, ramosis, $0.75\text{--}1.5 \mu$ diametro; conidiophoris brevibus, rectis vel ascendentibus ex hyphis sterilibus oriundis, $1.5\text{--}3 \mu$ diametro, 1–3-septatis, levibus, hyalinis vel laete coloratis, pauce ad apicem denticulatis vel leniter geniculatis; conidiis catenulatis, catenulis facile fractis, 1–3-septatis, levibus, hyalinis vel dilutissime coloratis, cylindraceutis, $16.5\text{--}36\text{--}45 \times 2\text{--}3 \mu$, leniter ad basim truncatum et ad apicem acute vel obtuse rotundatum fastigatis.

In foliis *Malvastri* sp., Venezuela.

Spots indistinct and "Tawny" above, "Cream Color" or "Cream Buff" below, up to 5 mm. in diameter, rounded or angular, occasionally coalescing. Sterile mycelium superficial or within the host, hyaline, septate, branched, $0.75\text{--}1.5 \mu$ in diameter; conidiophores as short erect or ascending branches from the sterile mycelium, $1.5\text{--}3 \mu$ in diameter, 1–3-septate, even, hyaline to slightly colored, few denticulate (1–5) or slightly geniculate at the apex of the terminal cell; conidia catenulate, the chains readily breaking apart, 1–3-septate, even, hyaline to very dilutely colored, cylindrical, slightly tapered to the truncate base and the obtusely or acutely rounded base, $16.5\text{--}36\text{--}45 \times 2\text{--}3 \mu$.

On *Malvastrum* sp., ravine at Adjuntas, south of Trompillo, 600 m. elev., Carabobo, Aug. 3, 1892, Chardon & Toro, Mycological Survey of Venezuela, 774.

This species appears to be distinct from other members of the genus that occur on malvaceous hosts. The predominantly external sterile mycelium, the morphology of the conidia and conidiophores set this species apart. It is somewhat difficult to obtain an accurate idea of the length of the spores of this species since they tend to elongate considerably as they germinate *in situ*, giving rise directly either to mycelium or else secondary conidia which are borne on denticles at the end of the primary conidia. However, the measurements given above are the average of those spores which have come free in the mounting medium (lactophenol).

***Stigmella graminicola* Linder, sp. nov. (FIG. F, 1-11.)**

Coloniis atris, superficialibus, compactis, pulverulentis, Ustilaginacearum simulantibus: myceliis sterilibus hyalinis vel subhyalinis, repentibus, ramosissimis et tegetem densam formantibus: conidiophoris forma ramarum brevium, rectarum vel adscendentium, ab myceliis sterilibus orientibus, hyalinis vel subhyalinis, laevibus, breve ramosis: conidiis dense congestis, $14.4-18 \times 12.5-16.5 \mu$, atro-fuscis, ovoideis vel ellipsoideis, ad apicem abrupte rotundatis vel saepe lobatis, ad basim truncatis, saepissime septis horizontalibus 1 raro 3 divis, cellula basali verticaliter 0-1-(2-) septata (raro cellula apicali non septata et cellula basilari verticaliter 1-3-septata), ad septa constrictis et parietibus minute et dense verruculosi.

Hab. in paniculis *Tricholaenae rosae* Lk. (?), prope Caracas, Venezuela.

Colonies superficial, compact, pulverulent, black and resembling a smut in gross appearance. Sterile mycelium hyaline or subhyaline, repent, much branched and forming a dense mat in the older portions. The conidiophores are hyaline to subhyaline, smooth, arising as short erect or ascending branches which in turn branch. The conidia measure $14.4-18 \times 12.5-16.5 \mu$, dark brown to nearly black and opaque, ovoid to ellipsoid and bluntly rounded or somewhat lobed at the apex, truncate at the base, irregularly septate, mostly 1-septate or occasionally 2-septate horizontally; the apical cell vertically 1-3-septate and the basal cell vertically 1-2-septate (less frequently the apical cell is non-septate and the basal or median cell is vertically 1-3-septate), the cells constricted at the septa, and the cell walls are minutely and closely finely warted.

In the panicles on the inflorescence and grain of *Tricholaena roseae* Lk. (?) near Caracas, Dist. Federal, Venezuela, Chardon & Toro, Mycological Exploration of Venezuela, 394.

This hyphomycetous fungus, which so closely resembles a smut, appears to be distinct from any species of the genus that have been described as growing on hosts belonging to the Gramineae. Because the spores do not aggregate or coalesce to produce large irregular multiseptate asexual fruiting structures, and because a

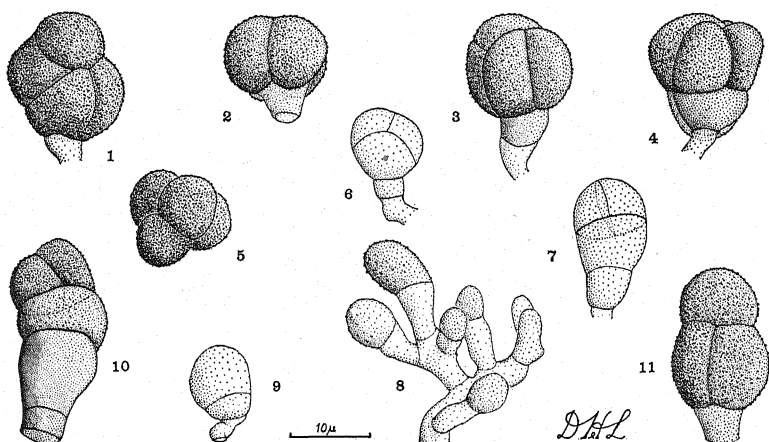


FIG. F. All figures drawn with the aid of a camera lucida at a magnification of 2350 \times before reduction. 1-5, mature conidia of *Stigmella graminicola* to show the common variations in the method of septation, those figured in 3 and 4 being the more typical; 5 represents the top view of a conidium; approximately \times 1175. 6-9, immature conidia and a portion of the fertile hyphae, the latter drawn as seen from above. The conidia are at first smooth and hyaline but soon, and as the spores become repeatedly divided by septations, become deeply colored and minutely though closely warted; approximately \times 1175. 10-11, mature conidia showing abnormal septation and size; approximately \times 1175.

definite though short conidiophore is present, it would appear that this form should be placed in the genus *Stigmella* rather than in the more or less nondescript genus *Coniothecium*. Among the species of the genus *Stigmella*, *S. Sacchari* Spegazzini (Rev. Facult. Agron. Vet La Plata 2 (19): 252-253. 1896) approaches this species most closely, but according to his description, the spores are divided at first by three horizontal septa to form a four-

celled structure, the middle cells of which are again divided by longitudinal septa. The conidia of the species at hand are divided by one, less frequently two, and rarely three horizontal septa. Most commonly only the terminal cell is divided by longitudinal septa (FIG. F, 2-4). However, the number and direction of the septa is somewhat variable (FIG. F, 1, 10, 11). The conidia of *S. Sacchari* are somewhat longer and proportionately narrower than are those of *S. graminicola* since, according to Spegazzini, they measure $20-30 \times 10-15 \mu$. The two species also differ in habitat for *S. Sacchari* Speg. grows on the leaves, sheaths, and culms, and causes but little or no damage to the host, whereas *S. graminicola* is confined to the florets through which the mycelium ramifies sufficiently to suppress the formation of grain. Indeed, it is possible that the developing caryopsis is first infected and that the fungus later spreads into the sterile floral parts. At all events, the differences in the morphology and biology of the two species is quite sufficient to warrant their separation and the recognition of *Stigmella graminicola* as a new species.

EXPLANATION OF FIGURES

All drawings have been made with the aid of a camera lucida from material mounted in lactophenol. The figures as reproduced are represented at a magnification of approximately $\times 500$.

Fig. A-B. *Cercospora Hurae* Linder & Whetzel. **A**, two spores and the conidiophores arising from a loosely organized stromatic base illustrate well the characteristics of this species; **B**, a less mature stromatic base is shown giving rise above to a conidiophore, and below, to a stolon-like hypha that grows out over the surface of the host. **Fig. C.** *Periconia Toroi* Linder. The conidiophore shown in full length, and the foreshortened one, illustrate well the secondary conidiophores which are arranged in a whorl below the apex of the main axis, and above the whorl are shown, either directly arising from the primary conidiophore or from the caducous secondary conidiophores, the spores which are often found in chains. **Fig. D.** *Ramularia Malvastris* Linder. Typical conidiophores of irregular shape and length are shown arising from the repent, superficial vegetative hyphae. Below are conidia showing the variation in shape and size of the conidia, and the method of germinating by producing secondary smaller spores. **Fig. E.** *Pucciniopsis Lonchocarpi* Linder. The numerous simple conidiophores are shown arising from the lighter colored stromatic base. At the right are shown a few of the colored, verruculose, uniseptate conidia.

A NEW FUNGUS INTERMEDIATE BETWEEN THE RUSTS AND SEPTOBASIDIUM

JOHN N. COUCH

(WITH 30 FIGURES)

While collecting *Septobasidium* in South Carolina a minute fungus was found which seems to combine to a remarkable degree some of the characters of the rusts and of *Septobasidium*. In its spore forms this fungus strikingly resembles certain rusts, while in its parasitism on scale insects it resembles *Septobasidium*. Since this fungus can be put neither in *Septobasidium* nor in any known genus of the rusts, it seems necessary to erect a new genus somewhat intermediate between these two groups.

Uredinella gen. nov.

Teleutospores uninucleatae, cylindricae vel pyriformes, brunneae. Binucleatae spores similes teleutosporis etiam formatae, quae non basidias sed binucleatas longe ellipticas parce curvas sporas generant.

Hab. supra Coccidas in quibus haustorio simili haustorio *Septobasidii* parasitantur.

Mature teleutospores uninucleate, cylindrical to pyriform with a distinct germ pore, brownish, giving rise to a typical, four-celled, septate basidium. Binucleate teleutospore-like structures also formed which give rise not to basidia but to binucleate, long-elliptic, slightly bent spores. Growing on scale insects which are parasitized by haustoria of the *Septobasidium* type.

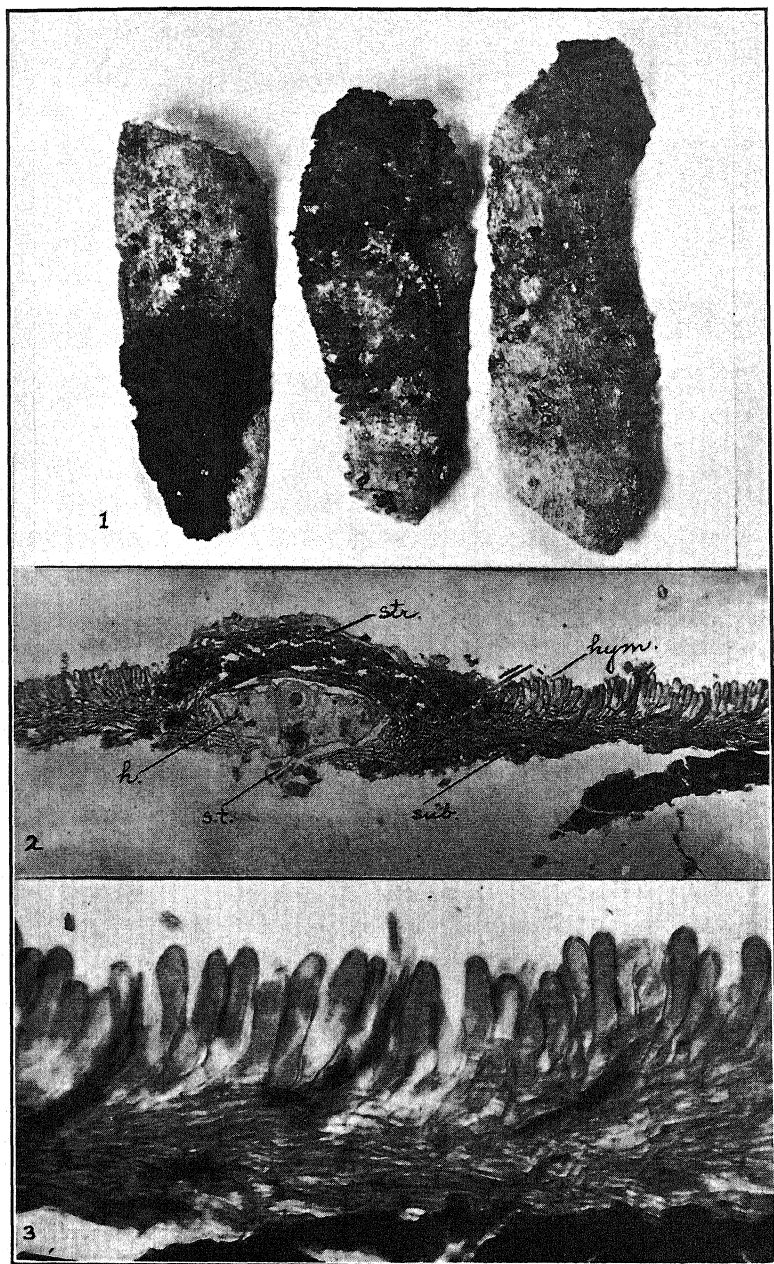
Uredinella coccidiophaga sp. nov.

Maculae minutae, 0.2–1.5 mm. diam., orbiculatae, effusae, annuae ad corticem arborum frondosarum, facile separabiles; colore valde castaneo vel brunneo; contextu firmo, sicco, 100–300 μ crasso. Teleutospores 10–17 \times 30–50 μ , germinantes apice forameni distincto et formantes cylindricum, 3-septatum basidium, 7.5–8.4 \times 48–54 μ ; sterigmata 7 μ ; spores curvae, ellipticae, 4.2–5.4 \times 16.8–21.8 μ . Binucleatae spores similes teleutosporis etiam formatae, quae binucleatas longe ellipticas parce curvas sporas generant.

Hab. supra Coccidas. Haustoria inaequaliter tortuose convoluta.

Forming minute, circular, flattened, discoid patches 0.2–1.5 mm. wide, on the bark of several deciduous trees, easily separable from the substratum, annual, always overgrowing a scale insect. Color very dark-chestnut to mummy-brown (Ridgway). Texture firm, dry, somewhat brittle. Surface smooth and velvety, or sometimes with bumps and radial ridges. Margin sharply determinate, frequently lighter colored than the main part of the fungus. In section 100–300 μ thick, consisting of compactly arranged basal hyphae extending radially and appearing pseudoparenchymatous in transverse section; hyphae hyaline to dark brown, septate, without clamps. Teleutospores arising from these hyphae and forming a compact hymenial layer with a few sterile hyphae intermingled. The older teleutospores near the center, though none formed directly over the scale insect, the younger ones near the margin. Teleutospores $10\text{--}17 \times 30\text{--}50 \mu$, ovoid to club-shaped or cylindric, most commonly thickest at the distal end. Teleutospore-wall composed of two layers, a thin outer layer hyaline in the basal part but brownish and thicker toward the top, smooth or warted toward the apex, and a thicker, inner, brownish layer. In some spores there appears to be a third layer, a thin, inner hyaline membrane. In the spore membranes there is a distinct apical germ-pore. Young teleutospores binucleate, becoming uninucleate early, before the wall is thickened, germinating in the spring when moist to form a cylindric, 4-celled basidium, $7.5\text{--}8.4 \times 48\text{--}54 \mu$; sterigmata typically arising from each cell, usually about 7μ long. Spores bent-elliptic, $4.2\text{--}5.4 \times 16.8\text{--}21.8 \mu$. A small amount of cytoplasm with a small nucleus remaining in each sterigma after spore-formation. Spores germinating in water by the formation of another sterigma and a secondary spore. Spores of another type in addition to the typical uninucleate teleutospore,

FIG. 1. Small dark patches of *Uredinella coccidiophaga*. *S. castaneum* Burt on lower half of piece to left. Natural size. 2, vertical section through part of a patch of fungal growth showing scale insect which was in center of patch. Note haustoria (h) in insect and sucking tube (st) of latter. Fungus penetrates insect in oral region and just above the sucking tube several pieces of penetrating hyphae are visible. Note also stromatic, sterile tissue (str) over insect; hymenium (hym.) and subiculum (sub.). $\times 107$. 3, enlarged view showing subiculum and hymenium. Note germ pores in teleutospores. $\times 486$.



FIGS. 1-3.

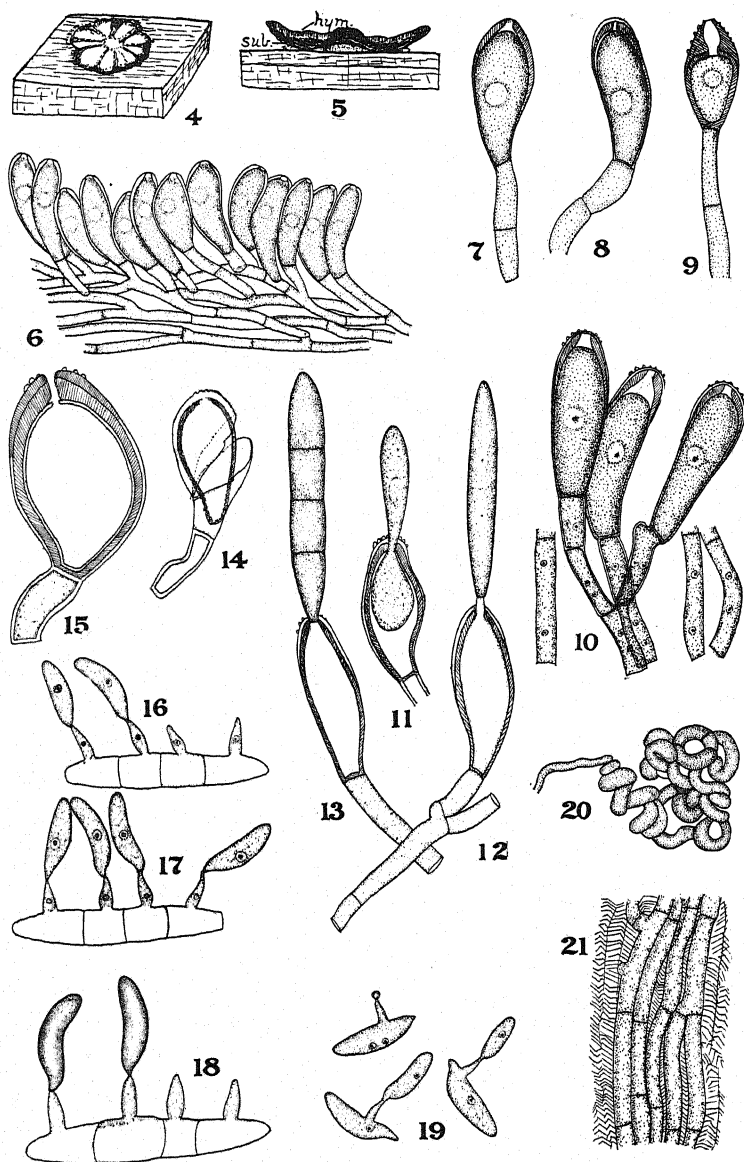


FIG. 4, surface sketch of fungus showing ridges, \times about 4.5; 5, diagrammatic section through entire fungus showing insect in center with its sucking tube; subiculum and hymenium, \times about 4.5; 6, section through hymenium showing teleutospores, \times 302; 7-9, teleutospores, \times 472; 10, teleutospore and mycelium cells, nuclei stained with cotton blue in Amann's lactophenol, \times 522; 11-13, germination of teleutospores to form basidia, \times 472; 14,

intermingled with the teleutospores and externally resembling them, are more uniformly cylindric and binucleate; and give rise to a binucleate, long-elliptic, slightly bent spore. At the end of the spore-producing season (perhaps early summer) the fungus dies and dries up.

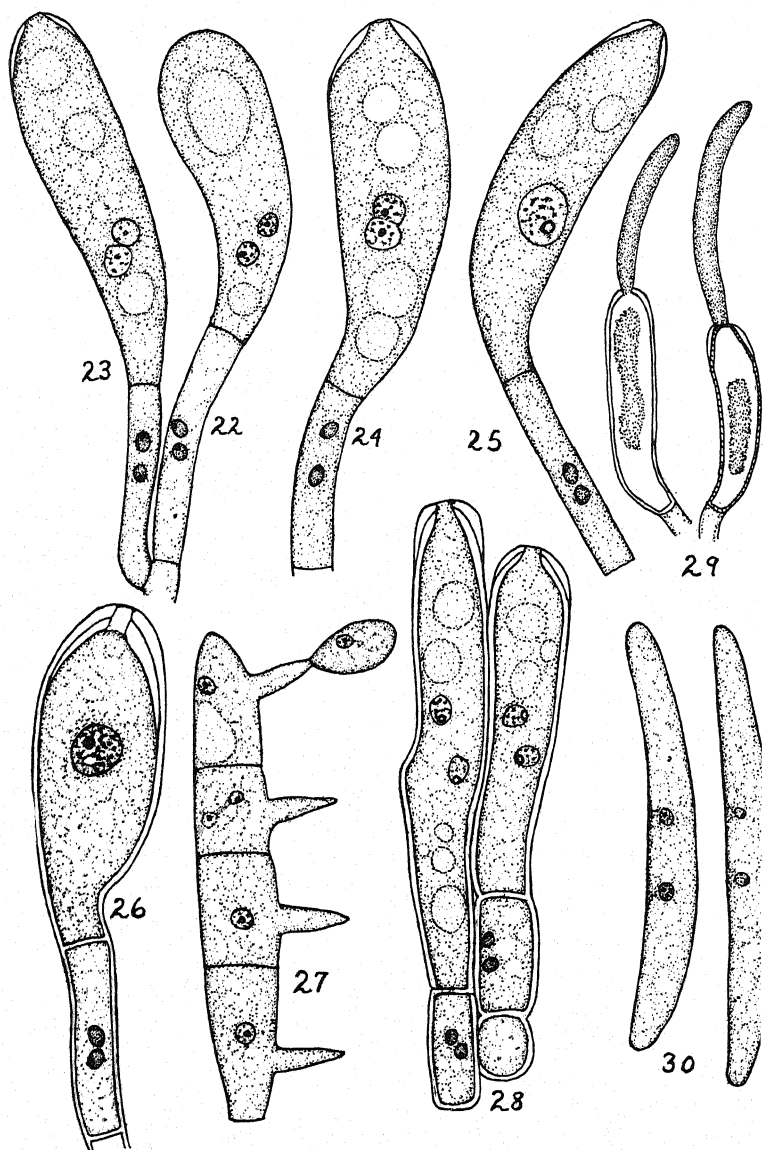
Associated with scale insects, one parasitized insect being beneath each patch of fungal growth. Haustoria of the irregular coiled type with sausage-shaped cells here and there. The connection between the haustoria and the external fungus is made around the insects' mouth.

Specimens examined: South Carolina: Near Charleston; on bark of *Quercus phellos*, parasitizing *Aspidiotus* sp., with *Septobasidium castaneum*, *S. pseudopedicellatum* and *S. sinuosum*, and *Myriangium* sp.; March 19, 1930, J. N. Couch, coll., No. 8468. Near Myrtle Beach, about 4 miles south on left side of beach road; abundant on *Ilex americana*, parasitizing *Aspidiotus* sp., with *Septobasidium castaneum*, and *Myriangium* sp.; April 25, 1937, J. N. Couch, coll., No. 10426 (type) in U. N. C. Herb.

NOTES ON CYTOLOGY

Because of the minute size of the fungus and its striking superficial resemblance to *Myriangium* sp., it could easily be overlooked or taken for the latter. In fact in the first lot of material collected, the fungus was not observed in the field but was accidentally discovered several months after it was collected when I was studying the margin of *S. castaneum* under the binocular dissecting microscope. By this time the peculiar bodies which I took to be teleutospores had so thoroughly dried that, though soaked over night in water, they failed to germinate. Having once carefully observed the fungus, it was possible to recognize it and to

empty teleutospore the outer membrane of which has been cracked, showing distinctly the inner, dark colored, thicker wall, $\times 472$; 15, section of empty teleutospore showing three apparent membranes, $\times 837$; 16-19, basidia and spores (note one nucleus in each spore except 19a and one in each sterigma in 16 and 17), 16, 17, and 19 drawn from material mounted in Amann's lactophenol and cotton blue; 18 drawn from material still floating on water, $\times 472$; 20, coiled haustorium from within body of parasitized insect, $\times 522$; 21, fungal threads growing over external body wall of insect, $\times 522$.



FIGS. 22-26, stages in nuclear fusion in the young teleutospore and thickening of wall and formation of germ pore (note nuclear fusion is completed before wall has become thick, $\times 1221$); 22-25, 27, and 30 from preparations stained by Gram's method; 26 and 28 iron alum haematoxylin staining; 27, basidium (note late nuclear division in one cell); in the apical cell note one nucleus in spore and one remaining in cell; sterigmata formed but nuclear

distinguish it from *Myriangium* even with the unaided eye. Though similar in size, the present fungus is brownish instead of black and has a flatter habit of growth than has *Myriangium*.

In April 1937 another trip was made to South Carolina to collect this fungus in the fresh condition in the hope that the peculiar teleutospores might be induced to germinate. Abundant material was found near Myrtle Beach, S. C., and was kept moist. Upon returning to Chapel Hill, the pieces of bark on which the fungus was growing were soaked in water for about thirty minutes and then put in damp chambers. An examination of several of the pieces after about 48 hours showed that some of the teleutospores had germinated to form a four-celled basidium. Maximum germination was obtained only when the material was kept well soaked. Indeed the largest number of basidia were obtained on pieces of material mounted in water under a cover slip. Such basidia, however, became septate as usual but failed to produce sterigmata and spores. After the basidium has reached its mature size and before the sterigmata are formed it usually falls away from the teleutospore, in nature perhaps usually adhering to the surface of the fungus.

If such basidia are floated on a drop of water, practically every one will produce sterigmata and spores, while the ones which sink to the bottom of the drop enlarge considerably but fail to germinate.

Due to the fact that the basidia break off from the teleutospores so easily, it was impossible to fix, section, and stain material showing the attached basidia. Also the mature teleutospore wall is very brittle and difficult to section. Gram's stain was good on the young teleutospores but poor on the mature ones. Iron alum haematoxylin showed good nuclei in all but division stages. Material which contained teleutospores with attached basidia mounted in Amann's lacto-phenol with cotton blue as a stain, showed the essential cytological features, but rather poorly. One very good slide with many basidia and spores was prepared by killing with

division has not yet occurred in two basal cells, $\times 1221$; 28, two uredospore mother cells each with thick brownish wall and two nuclei, $\times 1221$; 29, uredospore mother cells germinating to form uredospores, $\times 827$; 30, binucleate uredospores, $\times 1221$.

osmic acid fumes and staining with gentian violet (Gram technique). This showed the nuclei in the basidia and spores. No very clear division stages were seen. The cells of the mycelium are binucleate, as are also the young teleutospores. Nuclear fusion occurs in the young teleutospores while the walls are still thin, so that by the time the teleutospore is mature it is invariably uninucleate.

When the teleutospore germinates, the single large nucleus passes out with the protoplasm to form the basidium. Two nuclear divisions then follow in both of which the spindles appear to be longitudinal. Three transverse walls are formed cutting the basidium into four uninucleate cells. From each cell a sterigma now sprouts and when the sterigma has about reached its mature length, the nuclei each divide again so that each cell is binucleate. When the spore is formed, one nucleus passes into it; the other, with a little cytoplasm, remains in the sterigma. In this connection it is of interest to recall the behavior of the sterigmata of *Septobasidium Curtisii* (Berk. & Des.) Boed. & Stein. (Couch, Journ. E. M. Sci. Soc. 49: 156. 1933). Here the sterigmata remained full of protoplasm after the spores had been discharged and if kept moist gave rise to several, minute, ovoid bud cells. The sterigmata in *S. Curtisii* also undoubtedly contained nuclei as in the present species. If the spores are kept moist, each one forms a sterigma, the nucleus divides and one passes out with the cytoplasm into a secondary spore, while the other remains behind with some cytoplasm in the sterigma.

In addition to the teleutospore another kind of spore is formed. This spore is cylindrical as are some of the teleutospores and appears to be identical with the latter in wall structure. They differ from the teleutospores in being binucleate and in giving rise not to a basidium but to a non-septate, binucleate, long, bent-elliptic spore. These spores were fairly abundant and were found in all stages of formation from the thick-walled, teleutospore-like structures, and hence we can feel certain that these spores belong to the present fungus. Since they are binucleate and arise from the teleutospore mycelium they might be regarded as a peculiar type of uredospore. All efforts to induce the germination of these spores failed. The teleutospore-like structure which gives rise to

these peculiar uredospores might then be called the uredospore mother cell. So far as I have been able to find no spores like these have been described in any of the rusts.

SUMMARY

A new genus and species of fungus, *Uredinella coccidiophaga*, intermediate between the rusts and *Septobasidium* is described. The fungus produces a small, discoid, compact, annual growth which covers and is nourished by one scale insect, forming within the insect's body haustoria of the *Septobasidium* type. After producing spores in the spring, the fungus dies. Brown, thick-walled teleutospores are formed which in nuclear behavior, and external structure strikingly resemble the teleutospores of certain rusts. The basidia are four-celled and each cell is uninucleate at first. Before the spores are formed, nuclear division occurs in each cell. One nucleus goes into each spore and one remains with some cytoplasm in each sterigma. In water, the spores each produce a sterigma and another spore, the nuclear behavior in the basidial cells being repeated. In addition to the teleutospore, another type of spore is formed. This resembles the teleutospore in color and wall structure and resembles some of the teleutospores in being cylindrical in shape. It differs from the teleutospores in being binucleate and in producing a long, bent-elliptic, binucleate spore. The latter is regarded as a uredospore and the spore that bears it as a uredospore mother cell.

DEPARTMENT OF BOTANY,
UNIVERSITY OF NORTH CAROLINA,
CHAPEL HILL, N. C.

A NEW SPECIES OF CORDYCEPS WITH NOTES CONCERNING OTHER SPECIES¹

E. B. MAINS

(WITH 2 FIGURES)

In 1931, in Nova Scotia, L. E. Wehmeyer obtained two specimens of a *Cordyceps* which was unique in several respects. In 1934, A. H. Smith collected a number of specimens of the same fungus in the Adirondack region of New York. During the summer of 1936 the writer obtained one specimen in the El Cayo District of British Honduras and Dr. Smith obtained a specimen in Ontario.

This species is characterized by a limited cushion of fertile tissue which develops from a point on one side of the clava a short distance below the apex and partly surrounding the clava (FIG. 1, 2). This usually brings about an oblique development of the upper portion of the clava. *Cordyceps unilateralis* (Tul.) Sacc. occurring on ants in the tropics has a somewhat similar habit. It differs decidedly in color being described as blackish-brown. Also Petch (6) states that *C. unilateralis* is an *Ophiocordyceps* having fusoid ascospores 90μ long which do not break up into segments. The species under discussion is a true *Cordyceps* having filiform ascospores approximately as long as the ascus (330μ), the spores breaking up into segments. It apparently is an undescribed species for which the following name is proposed.

Cordyceps viperina sp. nov. (FIG. 1, 2).

Clavis singularibus, filiformibus, 5–15 mm. longis, 0.5 mm. crassis, aurantiis, acuminatis; peritheciis immersis in pulvinis, ovoideis, $330\text{--}440 \times 230\text{--}275\mu$, brevibus ostiolis; pulvinis 1.5–2.5 mm. latis, lateralibus sub apicibus; ascis cylindricis, $330 \times 8\text{--}10\mu$; ascosporis 8, filiformibus, in articulos $6\text{--}8 \times 2\mu$ mox fragmentibus.

Ex larvis scarabaeorum. Specimen typicum in Herb. Univ. Mich. conservatum A. H. Smith n. 387, Catlin Lake, N. Y., Aug. 1934.

¹ Paper from the Department of Botany and the Herbarium of the University of Michigan No. 633.

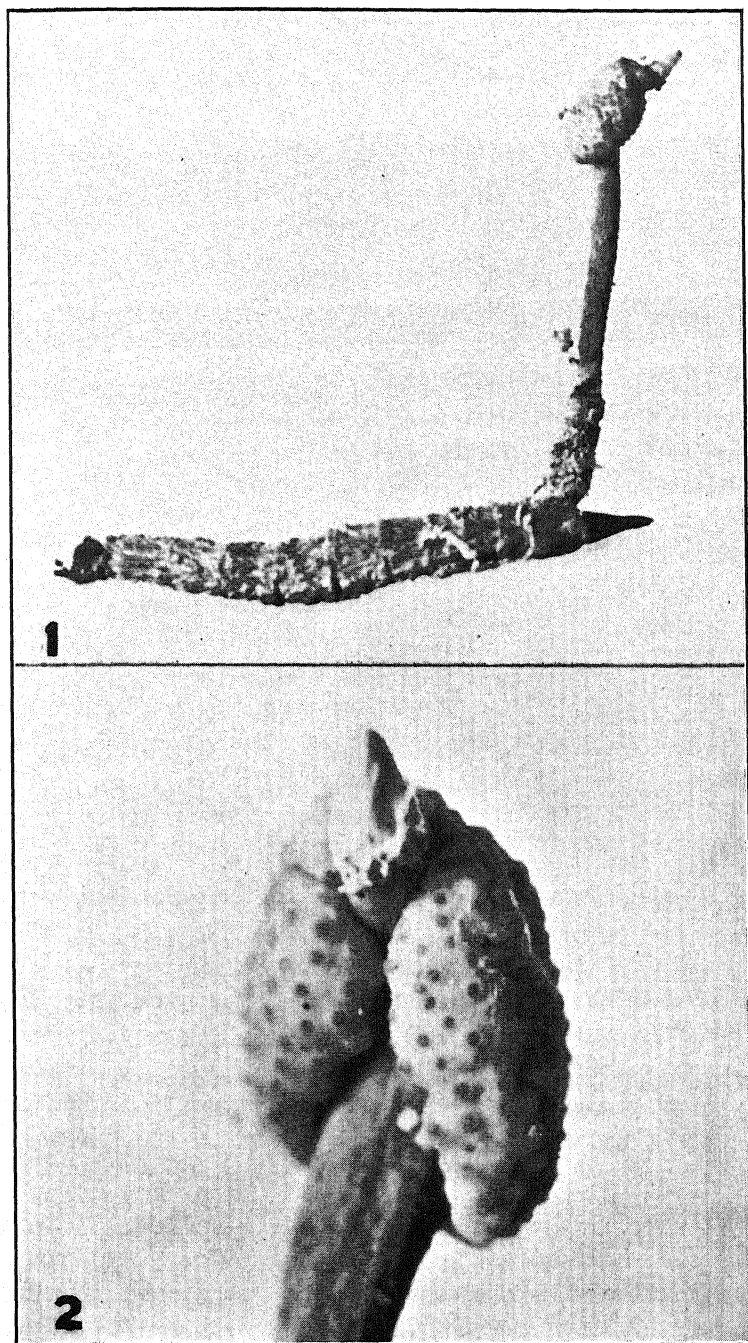


FIG. 1, clava of *Cordyceps viperina*, $\times 5$; 2, fertile cushion of stroma partly surrounding clava. $\times 18$.

Clavae single mostly from the posterior portion of larvae, slender, 5–15 mm. long, 0.5 mm. thick, orange, acuminate at the apex; perithecia embedded in a pulvinate stroma, ovoid, $330\text{--}440 \times 230\text{--}275 \mu$; ostioles short, slightly projecting; fertile stromata, pulvinate, 1.5–2.5 mm. wide, attached on one side below apices of clavae; asci cylindric, $8\text{--}10 \mu$ wide and up to 330μ long, the wall thickened abruptly at apex, up to 3μ ; ascospores filiform, parallel, nearly as long as the asci, multiseptate, beaking into segments $6\text{--}8 \times 2 \mu$.

On larvae of a beetle in rotten logs, Brookside, Nova Scotia, July 25, 1931, L. E. Wehmeyer (1213); Earltown Road, Nova Scotia, Aug. 23, 1931, L. E. Wehmeyer (1213a); Catlin Lake, New York, Aug. 19, 1934, A. H. Smith (387, type); Seventh Lake, New York, Aug. 22, 1934, A. H. Smith (425); North Creek, New York, Sept. 10, 1934, A. H. Smith (826); Warrensburg, New York, Sept. 16, 1934, A. H. Smith (883); Lake Timagami, Ontario, Aug. 26, 1936, A. H. Smith (4185); Cohune Ridge, El Cayo District, British Honduras, July 13, 1936, E. B. Mains (3837).

CORDYCEPS MICHIGANENSIS Mains.

This species which has been known from only two locations in Michigan (4) was collected on Bear Island, Lake Timagami, Ontario, Sept. 4, 1936, by A. H. Smith (4508).

CORDYCEPS SUPERFICIALIS (Peck) Sacc.

This species was described by Peck (5) from a collection obtained at Northville, N. Y., Aug. 1874. Kauffman (1) reported it from a collection obtained at South Haven, Michigan in 1910. A specimen has been received from H. S. Jackson (5043) collected Aug. 16, 1933, on Bear Island, Lake Timagami, Ontario. A collection obtained by G. D. Darker at Norwood, Mass., has also been recently distributed from the Farlow Herbarium of Harvard University (Rel. Farl. 704).

CORDYCEPS STYLOPHORA Berk & Br.

This is a rare species. Apparently it has previously been known only from Ravenel's collections in South Carolina and a collection

made by G. H. Hicks near East Lansing, Michigan, in 1892 (4). During the summer of 1934, A. H. Smith collected it repeatedly in New York at Warrensburg and Catlin Lake.

CORDYCEPS MELOLONTHAE (Tul.) Sacc.

A collection of this species obtained by A. H. Smith at Ann Arbor is the second record of the species for Michigan (4). Lloyd (2) has pointed out that the specimen of *Sphaeria herculea* Schw. in the Schweinitz herbarium is *Cauloglossum transversarium*. Mr. Don M. Benedict has kindly examined this specimen in the herbarium of the Philadelphia Academy of Science and agrees with Lloyd's conclusions. Both Lloyd (3) and Petch (7) have concluded that the name *Cordyceps Melolanthae* should apply to the fungus which has been passing under the name *C. herculea*.

OPHIOCORDYCEPS MACULARIS Mains.

This species has been known only from the type collected at Harbor Springs, Michigan (4). In September, 1934, A. H. Smith obtained one specimen at Kelm Mt., Warrensburg, N. Y.

LITERATURE CITED

1. Kauffman, C. H. Unreported Michigan fungi for 1910 with outline keys of the common basidiomycetes and ascomycetes. Ann. Rep. Mich. Acad. Sci. 13: 215-249. 1911.
2. Lloyd, C. G. Letter no. 47, note 98. 1913.
3. —. Mycological notes no. 39, 1915.
4. Mains, E. B. The genera *Cordyceps* and *Ophiocordyceps* in Michigan. Proc. Am. Phil. Soc. 74: 263-271. 1934.
5. Peck, C. H. Report of the Botanist. Ann. Rep. N. Y. State Mus. 28: 31-88. 1875.
6. Petch, T. Notes on entomogenous fungi, I. Trans. British Myc. Soc. 16: 55-75. 1931.
7. —. Notes on entomogenous fungi. Trans. British Myc. Soc. 19: 161-194. 1934.

PHOTOGRAPHS AND DESCRIPTIONS OF CUP-FUNGI—XXVIII. A PROPOSED GENUS

FRED J. SEAVER

(WITH 1 FIGURE)

A recent collection of *Peziza aurantiopsis* Ellis has prompted a more extended study of this interesting species. It was included in North American Cup-fungi, but with the statement that its generic position was in doubt. It had some of the characters of *Bulgaria*, some of *Urnulla*, and some of *Phillipsia*, but it failed to conform with any of these genera. A more recent study has convinced the writer that it is perhaps most closely related to *Urnulla*, possessing the black mycelium and the corky consistency which is especially characteristic of *Urnulla Geaster*. It can scarcely, however, be included as a species of that genus.

After a critical study of the species from fresh material the writer has decided to establish a new genus. Since the material prompting this study was sent by Dr. Frederick A. Wolf, it seems quite appropriate that the genus should be dedicated to him. Were this to be fitted into the scheme presented in North American Cup-fungi, it would probably appear in the Sarcoscyphaceae, between *Urnulla* and *Bulgaria*. Following is the diagnoses of the proposed genus and the type species.

Wolfina gen. nov.

Apothecia gregarious, sessile or tapering into a thick stem-like base made up of a compact mass of dark brown or blackish mycelium with which the outside of the apothecium is also covered, shallow cup-shaped the substance of the hypothecium thick white and decidedly corky in dried specimens; hymenium concave of a reddish color; asci cylindrical, 8-spored; spores uniseriate comparatively large; paraphyses filiform only slightly enlarged above.

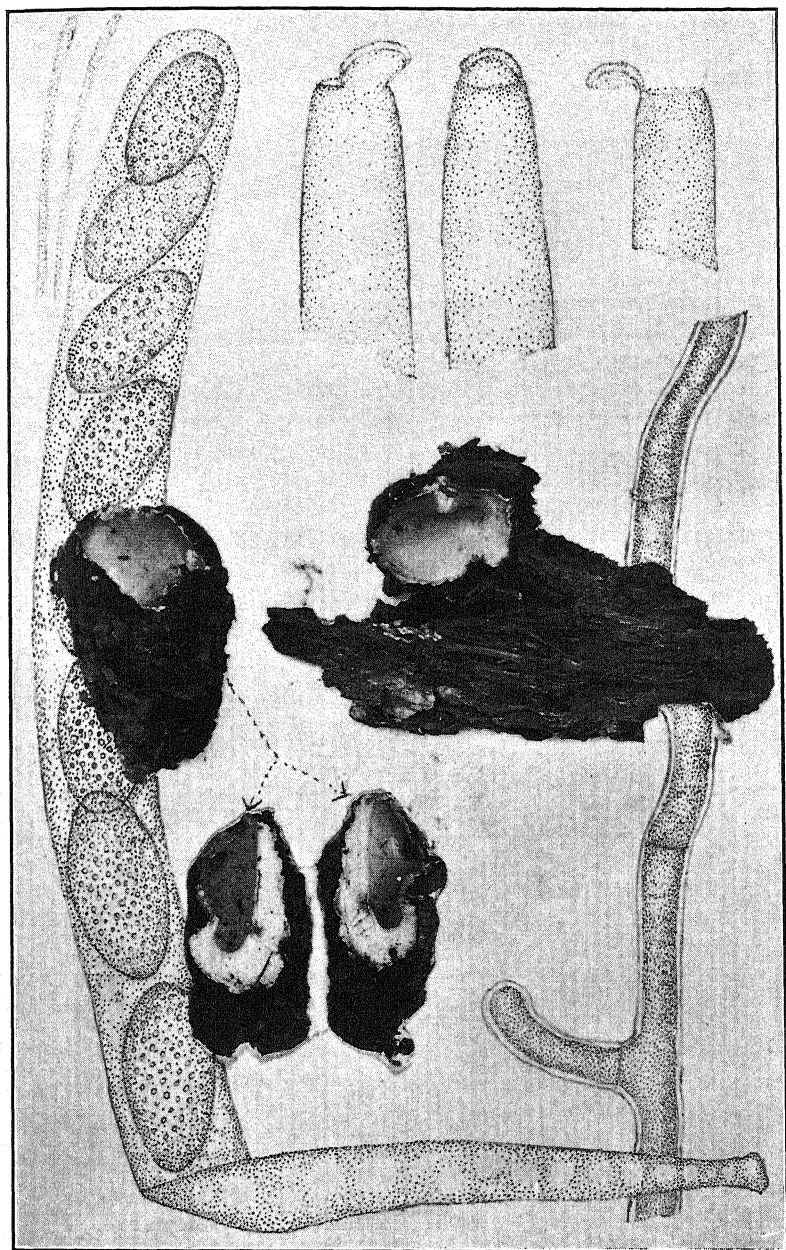


FIG. 1. *Wolfina aurantiopsis*.

***Wolfina aurantiopsis* (Ellis) comb. nov.**

Peziza aurantiopsis Ellis, Bull. Torrey Club 9: 18. 1882.

Lachnea aurantiopsis Sacc. Syll. Fung. 8: 180. 1889.

Scutellinia aurantiopsis Kuntze, Rev. Gen. Pl. 2: 269. 1891.

Apothecia gregarious, sessile, attached to the substratum by the entire under surface except the extreme margin which is free and slightly elevated and more or less incurved, externally brownish-black, the under side covered with numerous projecting folds, clothed with a dense growth of black mycelium, the substance within white, several mm. thick and in dried plants decidedly corky; hymenium pale-yellow or reddish, darker in dried plants; mycelium pale-brown, thin-walled, branched, septate, and externally often minutely rough; asci cylindric above, gradually tapering below into a stem-like base, reaching a length of $300\ \mu$ and a diameter of $17-18\ \mu$; spores 1-seriate or with the ends slightly overlapping, broad-ellipsoid, granular within, hyaline or slightly yellowish, $16-18 \times 27-33\ \mu$; paraphyses slender, slightly enlarged above and hyaline or nearly so, reaching a diameter of $3-4\ \mu$.

On bare soil and on decaying wood and leaves in low sandy oak and pine woods.

TYPE LOCALITY: Newfield, New Jersey.

DISTRIBUTION: New Jersey, Pennsylvania and North Carolina.

ILLUSTRATION: Seaver, Iowa Discom. *pl. 11, f. 2.*

THE NEW YORK BOTANICAL GARDEN

A DECAY OF ORNAMENTAL CACTI CAUSED BY *ASPERGILLUS ALLIACEUS*

J. J. TAUBENHAUS AND G. E. ALTSTATT¹

(WITH 1 FIGURE)

During 1933, about 40 per cent of the plants in a large planting of ornamental cactus in southwest Texas were found dead or in a dying condition. Infected pads at first showed numerous small, depressed, irregular, bluish to dark-brown spots which soon coalesced into large, sunken water-soaked areas, the affected pads collapsing or falling over, and suggesting a damping-off condition. At other times infection started at the upper part of the pads, but for some reason decay was soon arrested, leaving the lower portion unaffected and from which new growth originated. Within a few days the affected tissue became covered with a white to yellowish mycelial growth and numerous large black sclerotia and fruiting heads characteristic of an *Aspergillus*.

In the field planting of ornamental cacti mentioned above, the following varieties were found equally susceptible: *Acanthocereus pentagonis*, *Ancistrocactus Scheeri*, *Echinocereus chloranthus*, *Epithelantha micromeris*, *Neomammillaria microcarpa*, *Opuntia leptocaulis*, and *Echinocactus horizonthalonius*.

Cause: The numerous isolations made from infected pad tissue yielded pure cultures of a fungus identified as *Aspergillus alliaceus* Thom and Church.² This organism was found to grow on a variety of media some of which were unfavorable for sclerotia production. On potato-dextrose or corn-meal agar, the fungus produced copious mycelial growth, an abundance of sporophores and spores, and typical large sclerotia (FIG. 1 a). On lima bean agar, however, the fungus grew rather poorly and produced few

¹ Published with the approval of the Director as contribution No. 398 of the Texas Agricultural Experiment Station.

² Identification of this organism was checked by Dr. Charles Thom of the Microbiological Laboratory, Bur. Plant Industry, U. S. Dept. of Agriculture.

sporophores and spores and small sclerotia (FIG. 1 *b*). Platings on potato-dextrose agar, with hyphal tips, spores, and sclerotia resulted in typical colonies of *A. alliaceus*. In nature, the spread of the fungus is probably through spores, while the sclerotia may enable the organism to survive unfavorable soil and weather conditions, particularly during the hot summers of the South.

On a medium rich in carbohydrates, the mycelium of *A. alliaceus* is white and fluffy, gradually changes to a light-yellow, then to a deep-lemon color. Likewise, the young sporophores and spore heads are white but soon take on a yellow to brown color with age. The sclerotia are white when young, gradually turning brown, then dark, and are usually partly submerged in the substratum which has a tendency to wrinkle and crack, although the medium appears to be sufficiently moist. The measurements of the spores and of the sclerotia recovered from the ornamental cacti in Texas agree with those given by Thom and Church.³

Pathogenicity: During 1933, 12 normal potted cactus plants were obtained of each of the following varieties: *Acanthocereus pentagonis*, *Ancistrocactus Scheeri*, *Echinocereus chloranthus*, and the common spineless cactus, *Opuntia* sp. Both the pads and roots were carefully washed to remove all the soil, then dipped for one-half minute in a solution made up of 1-2000 bichloride of mercury in 25 per cent alcohol and rinsed three times in sterile water. The plants were then placed in moist chambers, six of each variety were inoculated through needle pricks with spores from a pure culture of *A. alliaceus* grown on potato-dextrose agar. Four other plants of each variety were inoculated through needle pricks with surface sterilized sclerotia from the same pure culture. The remaining two plants of each variety were pricked with a sterile needle and used as checks. Irrespective of the type of inoculum used, the inoculated plants developed typical decay and soon became covered with the characteristic mycelium, conidiophores, and sclerotia of the fungus, while uninoculated plants remained normal. Two replications of this series were made with similar results. The fungus was readily recovered from inoculated pads, proving that *A. alliaceus* is capable of causing a disease of ornamental

³ Thom, Charles, and M. B. Church. *The Aspergilli*, p. 163. Williams & Wilkins Co. Baltimore. 1936.

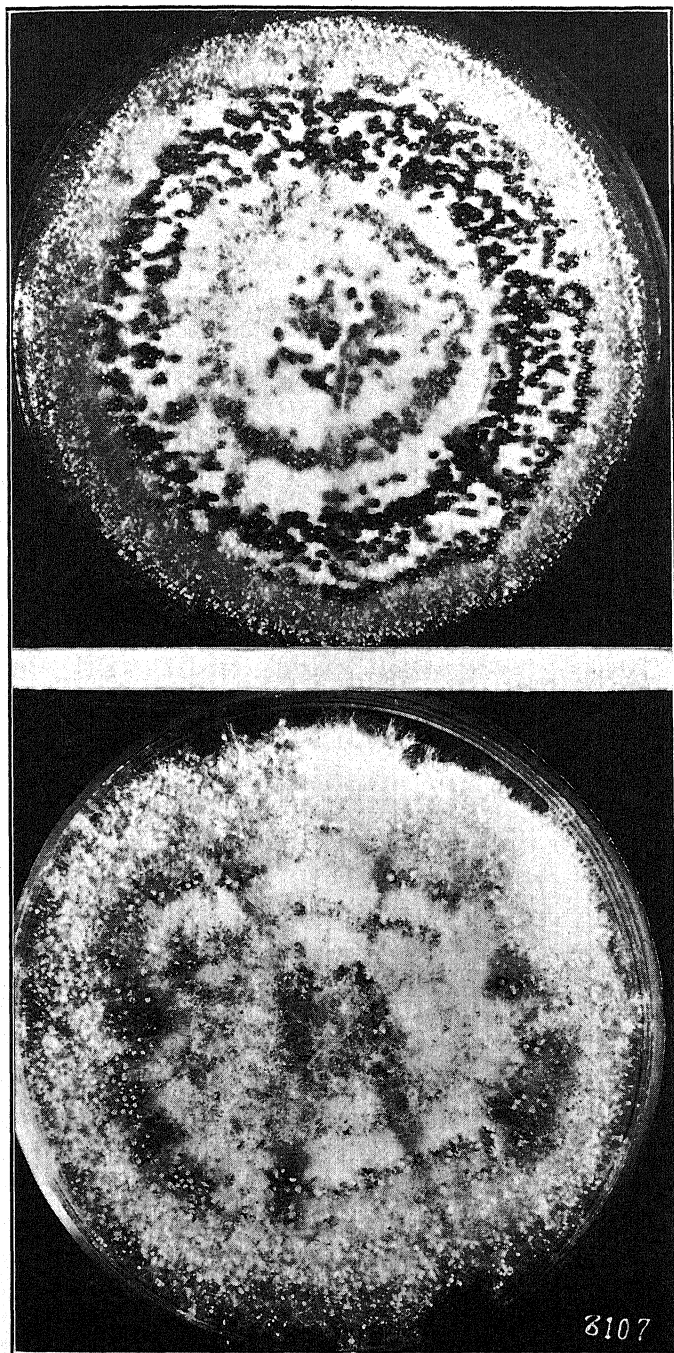


FIG. 1. Growth of *Aspergillus alliaceus* on two different media, (above) on

cacti. However, no infection resulted when the inoculum was placed on the unbroken epidermis of the pads even though they were kept under moist conditions, indicating that the fungus is probably a wound parasite only. Under field conditions, it is quite possible that insects or rodents may open the way to infection.

Susceptibility of hosts other than cacti: An attempt was made to determine whether *A. alliaceus* is able to infect various fruits and vegetables at room temperature. Inoculations were made on

TABLE 1
RESULTS OF INOCULATIONS OF VARIOUS HOSTS WITH SPORES AND SCLEROTIA
OF *Aspergillus alliaceus* FROM ORNAMENTAL CACTUS. INOCULATIONS
MADE AT VARIOUS INTERVALS FROM MARCH TO AUGUST, 1932

| Host Inoculated | Type of Inoculum | | | | Checks, Unin- oculated, Needle Prick Only | |
|------------------------------------------|--------------------------------|------------------------------|--------------------------------|------------------------------|----------------------------------------------------|-------------------------|
| | Spores | | Sclerotia | | Number Pricked | Number In- fected |
| | Num- ber Inocu- lated | Num- ber In- fected | Num- ber Inocu- lated | Num- ber In- fected | | |
| Spineless cactus, <i>Opuntia</i> sp..... | 12 | 11 | 12 | 9 | 7 | 0 |
| Apple, var. Delicious..... | 8 | 8 | 8 | 8 | 6 | 0 |
| Banana* | 12 | 12 | 12 | 12 | 5 | 0 |
| Orange, var. Valencia..... | 9 | 7 | 14 | 13 | 7 | 0 |
| Pineapple..... | 7 | 7 | 9 | 9 | 5 | 0 |
| Beets, var. Crosby Egyptian..... | 18 | 0 | 12 | 0 | 7 | 0 |
| Cabbage* | 5 | 0 | 5 | 0 | 3 | 0 |
| Carrots* | 12 | 0 | 12 | 0 | 12 | 0 |
| Cucumber, var. Chicago Pickling.... | 7 | 6 | 7 | 6 | 6 | 0 |
| Eggplant* | 5 | 5 | 5 | 3 | 5 | 0 |
| Onion, var. White Bermuda..... | 57 | 44 | 41 | 37 | 28 | 0 |
| Pepper* | 17 | 17 | 14 | 14 | 7 | 0 |
| Potato, var. Red Triumph..... | 25 | 0 | 25 | 0 | 20 | 0 |
| Tomato, var. Marglobe..... | 58 | 58 | 62 | 57 | 25 | 0 |
| Turnip, var. Purple Top..... | 10 | 9 | 14 | 11 | 9 | 0 |

* Variety unknown.

oranges, apples, tomatoes, Irish potatoes, eggplants, beets, pineapples, onions, carrots, peppers, cucumbers, bananas, and cabbage. Inoculations were made by needle pricks using either spores or sclerotia as the inoculum, after which the inoculated material was placed in moist chambers. From results in Table 1, it is noted that infection was obtained only in soft tissue fruits such as oranges, apples, tomatoes, eggplants, pineapples, onions, turnips, peppers, cucumbers, bananas, and cactus pads. No infection was secured on hard vegetables such as Irish potatoes, beets, carrots,

or cabbage. The symptoms on the several hosts inoculated differed but slightly from each other. In most cases, the inoculated material became soft, leaky, and covered by the characteristic hyphal growth, sclerotia, and sporophores of *A. alliaceus*. No infection resulted on any of the fruit or vegetables listed in Table 1, when the inoculum was placed on an unbroken epidermis, indicating further that *A. alliaceus* is probably a wound parasite.

Walker and Murphy⁴ reported two interceptions of *A. alliaceus* on decayed garlic imported from Italy into the United States, and succeeded in artificially infecting onions and garlic with a pure culture of this fungus. About the same time, Thom isolated *A. alliaceus* from a blister beetle in the United States. This would indicate that the fungus is probably of wide distribution, particularly in temperate and sub-tropical regions.

Control: During 1934, attempts were made to control this disease under field conditions with 4-4-50 Bordeaux mixture. In a field planting in southwest Texas of *Ancistrocactus Scheeri*, an ornamental cactus, 200 plants were divided into four equal plats. In Plat 1, the plants were sprayed with Bordeaux mixture; in Plat 2, both plants and soil were sprayed with Bordeaux mixture; in Plat 3, plants and soil were dusted with a commercial powdered dry Bordeaux; and in Plat 4, the plants left as checks. Although new infection appeared in all of the four plats, the best control was obtained in Plat 2 which had four per cent of the plants infected. On the other hand, 40 per cent infection occurred in Plat 3, 27 per cent in Plat 1, and 70 per cent in the check plat.

Summary: *A. alliaceus* is recorded as causing a pad decay of several species of ornamental cacti. This is believed to be the first record of the organism causing a decay of cultivated plants in the United States. The disease was reproduced by artificial inoculation on normal cactus pads, using either spores or sclerotia of the fungus as the source of inoculum. Successful inoculation occurred only when the organism was introduced through needle pricks. *A. alliaceus* was also shown to be able to cause a decay of several mature fruits and vegetables at room temperature. As with the inoculations on cacti, infection resulted only when the spores or the sclerotia of the fungus were introduced through needle pricks.

⁴ Walker, J. C. and Albert Murphy. Onion bulb decay caused by *Aspergillus alliaceus*. *Phytopath.* 24: 289-291. 1934.

THE SPECIES CONCEPT IN CORTICIUM CORONILLA¹

ROSEMARY BIGGS²

(WITH 26 FIGURES)

The Thelephoraceae include the simplest and least known members of the Hymenomycetes in which the hymenium shows no gross morphological differentiation. The distinction of species in the thin resupinate forms must rest almost exclusively on microscopic details. In the absence of a clear knowledge of the interrelationships within the group the choice of diagnostic characters must be to some extent arbitrary and as the concept of the family enlarges it is becoming evident that many of the microscopic features, at present emphasized in the descriptions of species, are inconsistent. For example, considerable importance is now attached to such characteristics as the presence or absence of incrusting material in the subiculum, the arrangement of the substratal hyphae, and the thickness of the fructification (Burt, 1926). In certain species these characters may be consistent and therefore of systematic value, on the other hand, in other species a sufficient number of specimens will include all possible variations of these characters. In addition to the confusion caused by the emphasis of inconsistent features, many of the common species show such a wide range of variation, when a large number of specimens are examined, as to suggest the inclusion of several species. In such cases, however, it is often difficult to find any clearly distinguishing characters.

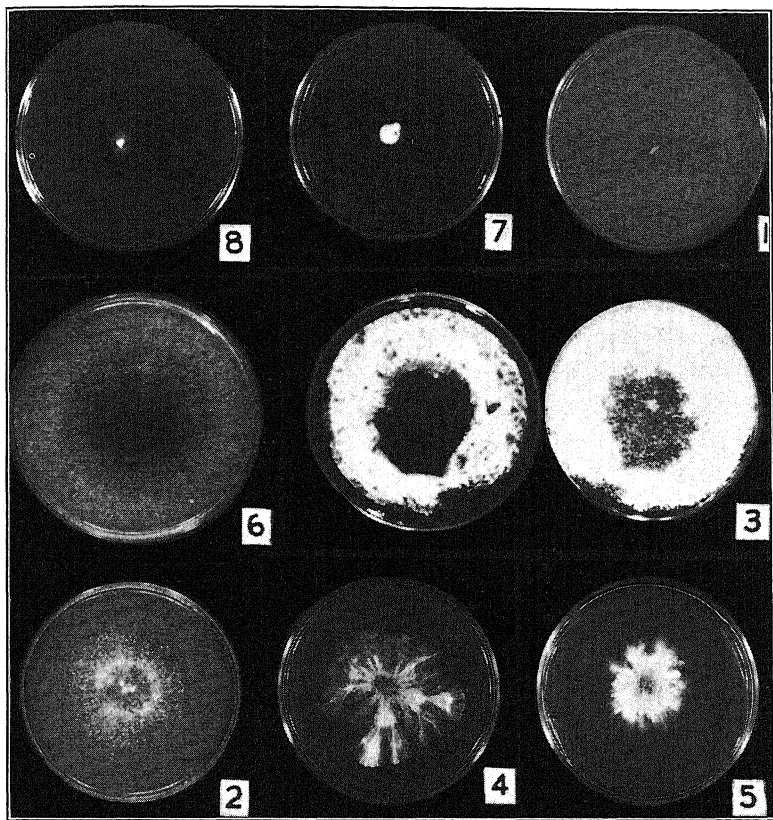
From attempts to work with these forms it has become evident that a more exact definition of the species concept in this group is extremely desirable. It was thought that a study of the cul-

¹ Contribution from the Department of Botany, University of Toronto.

² This study has been made under the direction of Dr. H. S. Jackson, to whom I wish to express my appreciation for his continued interest and helpful suggestions.

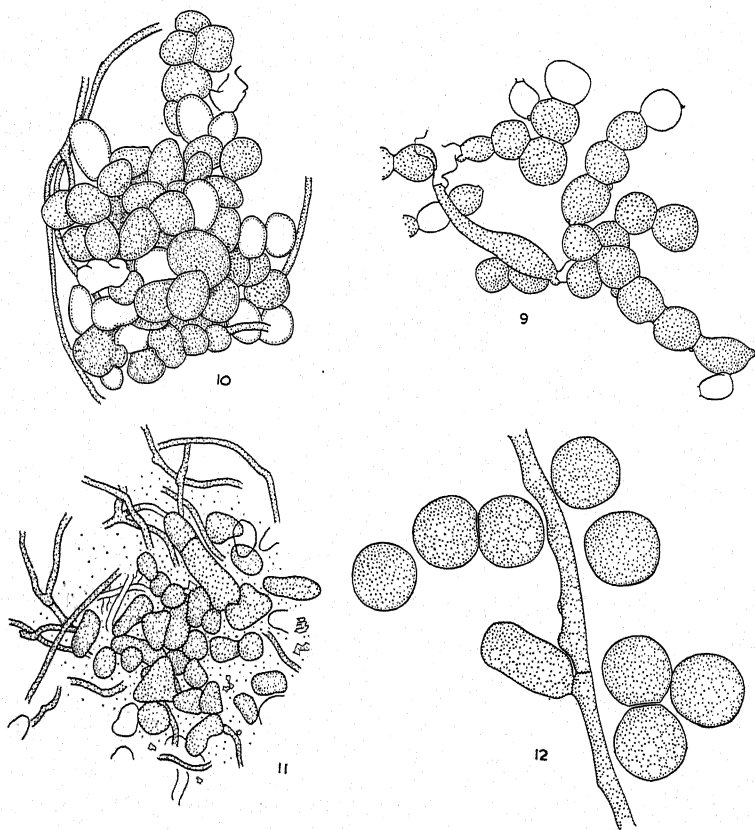
tural characters and pairing reactions within one of the more confusing species might provide additional criteria for the determination of relationships.

With this aim in view a study was made of a group of related



FIGS. 1-8. Growth characters of groups I-IV of *Corticium coronilla*: 1, group I, no. 585, 17 day culture, submerged growth covers the entire plate; 2, group II, no. 617, 17 day culture, conspicuous aerial mycelium; 3, group II, no. 617, 6 weeks culture, conspicuous basidiospore hymenium which has deposited a heavy white mass of spores on petri dish lid (left); 4, group IIIa, no. 773, 17 day culture, rhizoidal growth, bulbils produced at the centre of the colony; 5, group IIIa, no. 566, 17 days growth, pale brown bulbils at the centre of the colony; 6, group IIIb, no. 831, 17 day culture, rapid growth, cottony aerial mycelium, dark brown bulbils at the centre of the colony; 7, group IIIa, no. 566, 17 day culture, monosporous culture of limited growth; 8, group IV, no. 647, 17 day culture, very slight growth. All photographs $\times \frac{1}{4}$.

organisms which grow as thin white or yellowish films on decaying wood and which produce characteristic basidia, described as coronate and urniform. In these fungi a small ellipsoid probasidium is first formed, from the upper end of this a narrower neck grows out and at the apex of this a crown of five to eight sterigmata and



FIGS. 9-12. 9, bulbil-like cells produced by group II, no. 617; 10, true bulbil produced by group IIIa, no. 773; 11, mass of bulbil-like cells produced by a monosporous mycelium of limited growth, group IIIa, no. 566; 12, detachable swollen cells of group IV, no. 647. Magnified $\times 665$.

spores are produced (FIGS. 21-26). The wide range of structure occurring among the fungi answering to this general description has led to the recognition of four species of *Corticium* and one of *Grandinia*, viz.: *Corticium coronilla* v. Höhn. & Lit., *C. octo-*

sporum Schroet., *C. diademiferum* Bourd. & Galz., *C. niveo-cremeum* v. Höhn. & Lit., and *Grandinia Brinkmanii* (Bres.) Bourd. & Galz. A recent study by Rogers (1935) has led to the conclusion that these species are intergrading and that for practical purposes distinction is impossible. Rogers therefore includes all five species under the name *Sistotrema coronilla* (v. Höhn. & Lit.) Rogers. This new combination stresses the relationship implied in the presence of coronate urniform basidia in the genus *Sistotrema* but ignores the wide differences in organisation between the thin *Corticium* species and the stipitate hydroid *Sistotrema confluens* Pers., the type species of the genus *Sistotrema*. There can be little doubt that the type of the basidium

TABLE I
CULTURES OF *Corticium coronilla* v. Höhn. & Lit.

| Group Number | Culture Number | U. of T. Herbarium Number | Number of Mono-sporous Cultures | Number of Poly-sporous Cultures | Type of Heterothallism | Cultural Peculiarities |
|-------------------------------------------------|----------------|---------------------------|---------------------------------|---------------------------------|------------------------|-------------------------------------------------------------------------------------------|
| I | 585 | 10260 | 14 | 2 | Bipolar | Mycelium submerged and hyphae finally agglutinated and indistinct |
| | 586 | 10240 | 15 | 2 | Bipolar | |
| | 628 | 10263 | 8 | 2 | Bipolar | |
| | 629 | 10241 | 10 | 2 | Bipolar | |
| | 687 | 10257 | 15 | 2 | Bipolar | |
| II | 494 | 8218 | 25 | 2 | Homothallic | Cultures produce basidia |
| | 617 | 10267 | 20 | 2 | Homothallic | Cultures produce basidia |
| | 673 | | 0 | 3 | ? | Bulbil-like cells and basidia produced |
| | 709 | 10268 | 20 | 2 | Homothallic | Cultures produce basidia |
| | 714 | | 0 | 3 | ? | Bulbil-like cells and basidia produced |
| | 817 | 10266 | 37 | 2 | Homothallic | Bulbil-like cells and basidia produced |
| IIIa | 566 | 10246 | 26 | 2 | Tetrapolar | Bulbils and oidia produced |
| | 773 | 10244 | 14 | 2 | Tetrapolar | |
| IIIb | 831 | 10247 | 16 | 2 | Tetrapolar | Bulbils and oidia produced |
| IIIc | 506 | Farlow Herbarium | 0 | 2 | ? | Bulbils and oidia produced |
| IV | 647 | 10248 | 5 | 2 | Heterothallic | Slow mycelial growth, wide hyphae. Large spherical cells which separate from the mycelium |
| | 671 | 10254 | 0 | 2 | | |
| | 674 | 10250 | 0 | 2 | | |
| | 677 | 10251 | 0 | 2 | | |
| | 680 | 10249 | 0 | 2 | | |
| | 736 | 10253 | 0 | 2 | | |
| | 753 | 10252 | 0 | 2 | | |
| | | | | | | |
| Additional cultures not referred to groups I-IV | 519 | 10269 | 10 | 2 | ? | Bulbil-like cells produced |
| | 584 | 10262 | 0 | 2 | ? | Growth similar to that of group I |
| | 636 | 10242 | 0 | 2 | ? | |
| | 720 | 10255 | 0 | 2 | ? | |
| | 733 | 10245 | 0 | 2 | ? | |
| | 779 | 10243 | 0 | 2 | ? | |

is of fundamental phylogenetic importance. On the other hand, the whole basis of the generic and family classification most commonly in use in the Hymenomycetes rests on differences in gross morphology. This classification is, with little doubt, quite artificial but until the knowledge of the group as a whole is sufficiently advanced to warrant a general reorganisation on a more rational basis it would seem unwise to ignore the orthodox distinctions in any one isolated instance. For this reason, the comprehensive conception of the species *Sistotrema coronilla* (v. Höhn. & Lit.) Rogers is recognized but the name *Corticium coronilla* v. Höhn. & Lit. is retained to represent this collective entity.

Specimens referable to this species are extremely common in Ontario and cultures are easily made. From fourteen specimens sets of monosporous cultures were obtained. A list of these cultures is included in Table I.

Among these cultures four distinct groups could be recognized. These were so clearly delimited that a study of the cultures alone would give no indication that the original specimens of the different groups were in any way closely related.

The cultural characters of these four groups will first be described and then some attempt will be made to correlate these characters with the peculiarities of the original specimens.

Group I

In the first group, five sets of monosporous cultures were obtained. In these the growth on agar is rapid and mostly submerged (FIG. 1). The hyphae are of narrow diameter and, in the older parts of the colony, become so agglutinated as to be very indistinct. The polysporous cultures show clamp connections at every cross wall whereas the hyphae of the monosporous cultures are devoid of clamps. The individual monosporous cultures within each of the five sets of cultures were paired in all possible combinations. The pairing reactions were very indistinct. It was often impossible to find clamps in theoretically positive quadrants of the tables and occasionally the hook of the clamp failed to fuse with the penultimate cell as in the false clamp connections described by Quintanilha (1935). It was found that many of the unex-

pected negative reactions could be rendered positive by growing the two haplonts together on a thin film of agar. Under these conditions the hyphae would often develop clamp connections when these failed to appear in the tube cultures. In spite of the poor pairing reactions, the monosporous cultures of each of the five sets

| A ₅ | | | | | | | | | | a ₅ | | | | | | | | | |
|----------------|----|---|---|---|----|----|----|----|----|----------------|---|---|---|---|---|----|----|----|----|
| | | 4 | 5 | 9 | 12 | 13 | 14 | 16 | 18 | 1 | 2 | 3 | 6 | 7 | 8 | 10 | 11 | 15 | 17 |
| A ₅ | 4 | — | — | — | — | — | — | — | — | + | + | + | + | + | + | + | + | + | + |
| | 5 | — | — | — | — | — | — | — | — | + | + | + | + | + | + | + | + | + | + |
| | 9 | — | — | — | — | — | — | — | — | + | + | + | + | — | + | + | + | + | — |
| | 12 | — | — | — | — | — | — | — | — | + | + | — | + | + | + | + | + | + | + |
| | 13 | — | — | — | — | — | — | — | — | + | + | + | + | + | — | + | — | + | + |
| | 14 | — | — | — | — | — | — | — | — | — | + | + | + | + | + | + | — | + | + |
| | 16 | — | — | — | — | — | — | — | — | + | + | + | + | + | — | — | + | + | + |
| | 18 | — | — | — | — | — | — | — | — | + | + | — | + | + | — | + | + | + | + |
| a ₅ | 1 | + | + | + | + | + | — | + | + | — | — | — | — | — | — | — | — | — | — |
| | 2 | + | + | + | + | + | + | + | + | — | — | — | — | — | — | — | — | — | — |
| | 3 | + | + | + | — | + | + | + | — | — | — | — | — | — | — | — | — | — | — |
| | 6 | + | + | + | + | + | + | + | + | — | — | — | — | — | — | — | — | — | — |
| | 7 | + | + | — | + | + | + | + | + | — | — | — | — | — | — | — | — | — | — |
| | 8 | + | + | + | + | — | + | — | — | — | — | — | — | — | — | — | — | — | — |
| | 10 | + | + | + | + | + | — | + | — | — | — | — | — | — | — | — | — | — | — |
| | 11 | + | + | + | + | — | — | + | + | — | — | — | — | — | — | — | — | — | — |
| | 15 | + | + | + | + | + | + | + | + | — | — | — | — | — | — | — | — | — | — |
| | 17 | + | + | — | + | + | + | + | + | — | — | — | — | — | — | — | — | — | — |

TABLE II

PAIRING REACTIONS OF 18 MONOSPOROUS MYCELIA OF *Corticium coronilla*
GROUP I, No. 687. + = NORMAL CLAMP CONNECTIONS. + = POOR
REACTION. — = ABSENCE OF CLAMP CONNECTIONS.

could be separated into two groups indicating a bipolar type of heterothallism. A typical table of pairing reactions is included as Table II. When representative monosporous mycelia from different sets of cultures were paired all the reactions were positive (Table III).

TABLE III
PAIRING REACTIONS OF REPRESENTATIVE MONOSPOROUS MYCELIA FROM
FIVE COLLECTIONS OF *Corticium coronilla* GROUP I

| | | 585 | | | | 628 | | | | 629 | | | | 687 | | | |
|-----|----------------|----------------|---|----------------|---|----------------|---|----------------|---|----------------|---|----------------|---|----------------|---|----------------|----|
| | | A ₁ | | a ₁ | | A ₃ | | a ₃ | | A ₄ | | a ₄ | | A ₅ | | a ₅ | |
| | | 3 | 8 | 2 | 5 | 1 | 2 | 3 | 8 | 2 | 3 | 7 | 9 | 4 | 5 | 1 | 15 |
| 586 | A ₂ | 1 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | | 2 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | a ₂ | 5 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| | | 6 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |

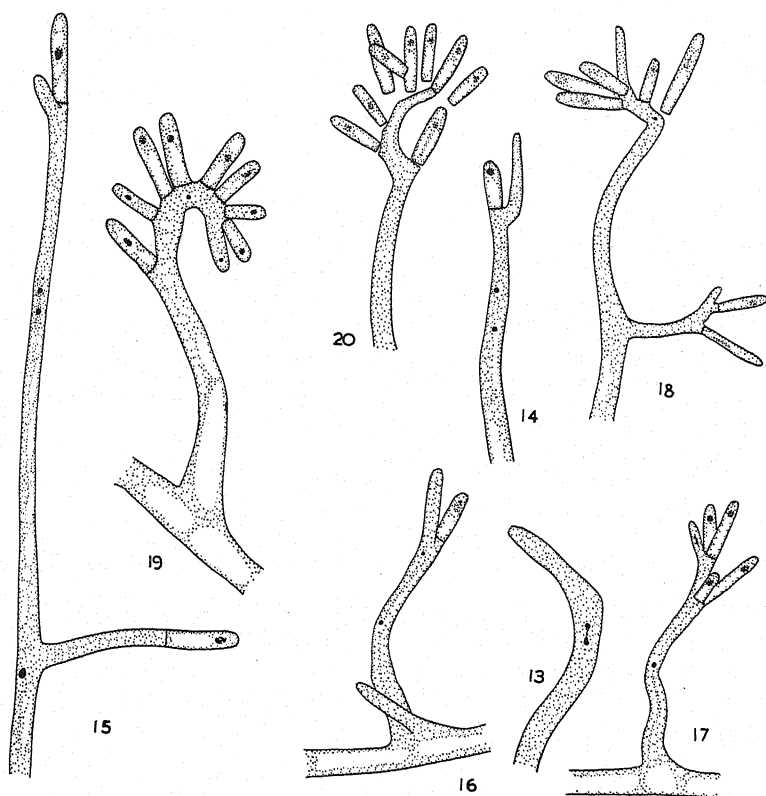
Group II

From four of the six specimens separated in the second group, sets of monosporous cultures were obtained and from two polysporous cultures were isolated. In all these cultures the growth is rapid and a considerable amount of aerial mycelium develops. Both monosporous and polysporous cultures show more or less of a tendency to produce basidia (FIGS. 2 and 3). In three strains (no. 673, no. 714 and no. 817) some large rather thickwalled cells occur. These bear a marked resemblance to the constituent cell of the bulbils described for group III and to the swollen cells of group IV (FIGS. 9-12). The hyphae of both monosporous and polysporous cultures develop clamp connections indicating that the fungi in this group are homothallic. A cytological study showed that the basidia regularly contain fusion nuclei, the spores are uninucleate and the hyphae are binucleate. The homothallism of this strain may be compared with that of *Coprinus sterquilinus* Fries described by Miss Mounce (1921) and others. In this species also the hyphae produced clamp connections and the whole life cycle is completed from a single nucleus.

Group III

From three specimens included in this group sets of monosporous cultures were obtained and from one other a polysporous culture

was isolated. In all of these cultures a conspicuous aerial mycelium is produced and the central portion of the colony is covered by masses of brown bulbils (FIGS. 4, 5, 6). These bulbils are small groups of fungus cells which become differentiated and agglutinated together, and finally separate from the vegetative my-



FIGS. 13-20. Successive stages in oidial production in *Corticium coronilla* group IIIa, no. 566. Magnified $\times 1600$.

celium (FIG. 10). In addition to the bulbils produced in both the monosporous and polysporous cultures, oidia are produced in sympodial clusters on aerial branches of the monosporous mycelia. These aerial hyphae are normal haploid hyphae with uninucleate cells on which the oidiophores occur as wide angled side branches. On each of the oidiophore side branches oidial development takes place successively. The nucleus of the oidiophore divides and

one of the daughter nuclei passes to the tip of the hypha and is cut off in an oidium (FIGS. 13-20). A second oidium forms at the base of the first and the oidiophore nucleus again divides. The second oidium tends to assume a terminal position. Development proceeds in this sympodial fashion until a small head of oidia is formed. As far as could be ascertained these oidia are consistently

| | | A_1B_1 | | | | | a_1b_1 | | | a_1B_1 | | | | A_1b_1 | | | | | | | |
|----------|----|----------|----|----|----|----|----------|---|---|----------|---|---|----|----------|----|----|---|---|---|---|----|
| | | 8 | 11 | 13 | 15 | 19 | 20 | 1 | 3 | 12 | 7 | 9 | 10 | 14 | 17 | 18 | 2 | 4 | 5 | 6 | 16 |
| A_1B_1 | 8 | - | - | - | - | - | - | + | + | + | - | - | - | - | - | - | - | - | - | - | - |
| | 11 | - | - | - | - | - | - | + | + | + | - | - | - | - | - | - | - | - | - | - | - |
| | 13 | - | - | - | - | - | - | + | + | + | - | - | - | - | - | - | - | - | - | - | - |
| | 15 | - | - | - | - | - | - | + | + | + | - | - | - | - | - | - | - | - | - | - | - |
| | 19 | - | - | - | - | - | - | + | + | + | - | - | - | - | - | - | - | - | - | - | - |
| a_1b_1 | 20 | - | - | - | - | - | - | + | + | + | - | - | - | - | - | - | - | - | - | - | - |
| | 1 | + | + | + | + | + | + | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | 3 | + | + | + | + | + | + | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| a_1B_1 | 12 | + | + | + | + | + | + | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | 7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + | + | + |
| | 9 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + | - | + | + | + |
| | 10 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + | + | + |
| | 14 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + | - | + | + |
| A_1b_1 | 17 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + | + | + |
| | 18 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | + | + | + | + | + |
| | 2 | - | - | - | - | - | - | - | - | - | + | + | + | + | + | + | - | - | - | - | - |
| | 4 | - | - | - | - | - | - | - | - | - | + | + | + | + | + | + | - | - | - | - | - |
| | 5 | - | - | - | - | - | - | - | - | - | + | + | + | + | + | + | - | - | - | - | - |
| A_1b_1 | 6 | - | - | - | - | - | - | - | - | - | + | + | + | + | + | + | - | - | - | - | - |
| | 16 | - | - | - | - | - | - | - | - | - | + | + | + | + | + | + | - | - | - | - | - |

TABLE IV

PAIRING REACTIONS OF 20 MONOSPOROUS MYCELIA OF *Corticium coronilla* GROUP IIIa, No. 566

absent from the diploid, polysporous cultures. The hyphae of the monosporous cultures lack clamp connections, while those of polysporous origin produce clamps. When the monosporous cultures from a single fructification were paired in all possible combinations these could be separated into four groups with regard to the production of clamp connections indicating a tetrapolar type of hetero-

thallism. The pairing reactions of one set of monosporous cultures, no. 566, are given in Table IV.

There is some variation in this group suggesting the separation into three subgroups:

Subgroup a

In this subgroup two sets of monosporous cultures, no. 566 and no. 773 belong. The polysporous cultures of these fungi develop a conspicuous aerial rhizoidal growth and the bulbils are of a pale-brown color (FIGS. 4 and 5). In no. 773 the monosporous cultures are similar to those of polysporous origin. In no. 566, on the other hand, the monosporous cultures show a striking variation. In some the growth is similar to that of the polysporous cultures while in others an extremely limited growth occurs and the mature colony is an irregular mass of agglutinated hyphae in which bulbil like cells occur but no true bulbils are produced (FIGS. 7 and 11).

When representative monosporous mycelia from no. 773 and no. 566 were paired, clamps were produced in all combinations (Table V).

Subgroup b

To this subgroup the set of monosporous cultures, no. 831, belongs. In both monosporous and polysporous cultures a cottony aerial mycelium is developed which shows no tendency to rhizoidal growth. The bulbils produced are of a dark brown color (FIG. 6). When representative monosporous cultures of no. 831 were paired with those of no. 773 the reaction was completely negative (Table V).

The fungus separated in this subgroup is evidently related to the fungi in subgroup *a*. Bulbils and oidia are produced in both subgroups and in both the heterothallism is of the tetrapolar type. On the other hand, the lack of rhizoidal growth, the different color of the bulbils and the failure to react with one another would indicate that the two are distinct.

TABLE V

PAIRING REACTIONS OF REPRESENTATIVE MONOSPOROUS MYCELIA OF GROUP IIIa, No. 566 AND No. 773, AND GROUP IIIb, No. 831

| | | | 566 | | | | | 831 | | | |
|-----|-------------------------------|---|-------------------------------|-------------------------------|-------------------------------|-------------------------------|--|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| | | | a ₁ b ₁ | A ₁ b ₁ | A ₁ B ₁ | a ₁ B ₁ | | a ₃ B ₃ | a ₃ b ₃ | A ₃ B ₃ | A ₃ b ₃ |
| | | | 1 | 2 | 8 | 10 | | 1 | 2 | 3 | 5 |
| 773 | A ₂ B ₂ | 1 | + | + | + | + | | — | — | — | — |
| | a ₂ b ₂ | 5 | + | + | + | + | | — | — | — | — |
| | A ₂ b ₂ | 4 | + | + | + | + | | — | — | — | — |
| | a ₂ B ₂ | 8 | + | + | + | + | | — | — | — | — |

Subgroup c

One polysporous culture is placed in this subgroup. The cultural characters of this fungus are similar to those of the fungi in subgroup *a*. However, the microscopic characters of the specimen, to be described later, are very distinct and had monosporous cultures been available it is very probable that these would have failed to react with the other groups.

It is interesting to note that this group of *Corticium coronilla* almost certainly includes the fungus previously described by Lyman (1907) under the name of *Corticium alutaceum* (Schrad.) Bres. The bulbils and oidia produced by *Corticium coronilla* group III correspond exactly to those described by Lyman. Cultures have been repeatedly obtained from collections of *Corticium radiosum* Fries, to which species Burt (1926) assigns *C. alutaceum* as a synonym, and neither bulbils nor oidia were ever observed. The description given by Lyman (1907) for the specimen of "*Corticium alutaceum*" from which his cultures were obtained states that the fungus was thin, with a rather indeterminate sometimes fibrillose edge, with basidia bearing four to eight sterigmata. Associated with these hymenia conspicuous bulbil fructifications occurred. This description is more reminiscent of *Corticium coronilla* than *Corticium radiosum*. Further, specimens under the name of *Corticium alutaceum* were obtained from the Farlow herbarium, having been collected in the same general region from

which Lyman obtained his material. These specimens lacked well developed hymenia but the general appearance was very similar to that of *Corticium coronilla* group III (c). Finally this specimen of group III (c) was sent by Dr. Linder, having been collected in the region in which Lyman worked. From this it would seem evident that the fungus described by Lyman was in no way related to *Corticium radiosum* Fries, but was very similar to *Corticium coronilla* v. Höhn. & Lit. group III. Lyman's strain was probably distinct from the three strains of *C. coronilla* group III described, the spores were said to measure $3.8-4.5 \times 5.8-6.5 \mu$, which is considerably larger than those found in any of the specimens studied.

Although bulbils are always present in the cultures of the fungi assigned to Group III these structures were only found associated with the specimen of group III c (no. 506). The reason for the absence of bulbils from the specimens of group III a and b was not determined. It is, however, possible that these structures are produced most readily in the spring. The specimen of *C. coronilla* group III c and the bulbil producing specimens referred to *C. alutaceum* were collected early in the season, while the specimens of group III a and b were collected between July and October. Had these specimens been collected in the spring it is possible that bulbils might have been found in association with the hymenium.

Group IV

In this group one small set of five monosporous cultures was obtained and from four additional specimens polysporous cultures were isolated. In contrast to the three first groups, in which the spores germinated readily on agar, the spores of the fungi in this group germinated only after a rest of three or four days and then in very low percentage. The growth on agar is very slow (FIG. 8). The hyphae which are of wide diameter and not at all agglutinated produce an abundance of conspicuous spherical cells which finally become detached (FIG. 12). These spherical cells are large and more in the nature of chlamydospores than conidia; they bear some resemblance to the swollen cells produced by the

fungi in group II and to the constituent cells of the bulbils in group III. A relationship between the fungi in these three groups may be indicated by the similarity of these structures. The few monosporous cultures which were obtained failed to develop clamp connections and on pairing could be separated into two groups. This strain is then evidently heterothallic.

TABLE VI

PAIRING REACTIONS OF REPRESENTATIVE MONOSPOROUS MYCELIA OF
Corticium coronilla GROUP I, No. 568, WITH GROUP IIIa, No. 566
AND No. 773, GROUP IIIb, No. 831, AND GROUP IV, No. 647

| | | 566 | | | | 773 | | | | 831 | | | | 647 | | | |
|-----|----------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-----|---|---|---|
| | | a ₁ b ₁ | A ₁ b ₁ | A ₁ B ₁ | a ₁ B ₁ | A ₂ B ₂ | a ₂ B ₂ | A ₂ b ₂ | a ₂ B ₂ | a ₃ B ₃ | a ₃ b ₃ | A ₃ B ₃ | A ₃ b ₃ | A | a | | |
| | | 1 | 2 | 8 | 10 | 1 | 5 | 4 | 8 | 1 | 2 | 3 | 5 | 1 | 4 | 2 | 3 |
| 568 | A ₂ | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| | 2 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| | 5 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| | a ₂ | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| | 6 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |

TABLE VII

PAIRING REACTIONS OF REPRESENTATIVE MONOSPOROUS MYCELIA OF
Corticium coronilla GROUP IV, No. 647, WITH GROUP IIIa,
No. 773, AND GROUP IIIb, No. 831

| | | 773 | | | | 831 | | | |
|-----|---|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| | | A ₂ B ₂ | a ₂ B ₂ | A ₂ b ₂ | a ₂ B ₂ | a ₃ B ₃ | a ₃ b ₃ | A ₃ B ₃ | A ₃ b ₃ |
| | | 1 | 5 | 4 | 8 | 1 | 2 | 3 | 5 |
| 647 | A | 1 | — | — | — | — | — | — | — |
| | | 4 | — | — | — | — | — | — | — |
| | a | 2 | — | — | — | — | — | — | — |
| | | 3 | — | — | — | — | — | — | — |

When test monosporous mycelia from groups I, III and IV were paired with each other the reactions were negative in all combinations (Tables VI and VII).

Recapitulating these results, the fungi in group I are characterized by a rapid growth of submerged hyphae and the hetero-

thallism is of the bipolar type. The fungi in group II tend to produce basidia in artificial culture and all the monosporous mycelia develop clamp connections, indicating that the strain is homothallic. The fungi in group III all produce bulbils and oidia and in all the heterothallism is of the tetrapolar type. In group IV the fungi do not grow readily in culture, the hyphae are of wide diameter and produce conspicuous spherical swellings.

Since the fungi could so readily be separated into four groups on their cultural characters, the original specimens were examined in order to establish some correlated morphological peculiarities. In the following descriptions the minute differences, which were associated with each of the groups, have been stressed.

Group I (FIG. 21)

Fructification delicate, coarsely powdery with some tendency to develop *Grandinia* granules. Edge indeterminate. Subiculum usually with some included crystalline matter. Hyphae distinct or indistinct according to the specimen, usually about $3\ \mu$ in diameter. Basidia usually $12-14 \times 3-4\ \mu$. Spores ellipsoid, cylindric, not curved, $1.8-2 \times 3-4.5\ \mu$.

Specimens examined: Ontario: Temagami, R. Biggs, Univ. of Toronto Herb. numbers 10240, 10241, 10257, 10260; Temagami, H. S. Jackson, Univ. of Toronto Herb. number 10263.

Group II (FIG. 22)

Fructification usually thicker than in group I, producing conspicuous *Grandinia* granules. Edge indeterminate. Hyphae distinct or indistinct, usually rather irregular, $2-5\ \mu$ in diameter. Basidia very variable $3-4 \times 13-20\ \mu$. Spores cylindric and usually curved $1.8-2 \times 3.5-5\ \mu$.

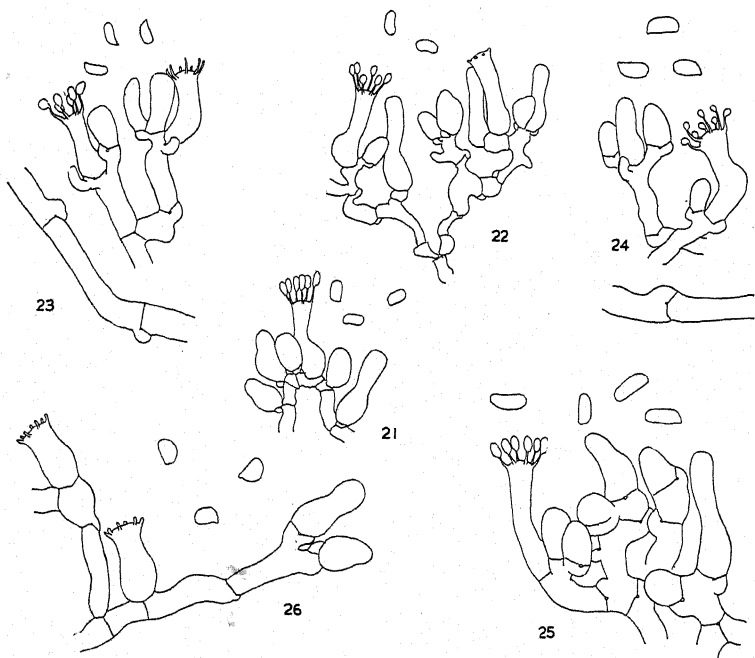
Specimens examined: Ontario: Temagami, R. Biggs, Univ. of Toronto Herb. numbers 10264, 10265, 10267, 10268; Brant County, R. F. Cain, Univ. of Toronto Herb. number 10266.

Group III (a) (FIG. 23)

Fructification pellicular with a distinct fibrillose edge, with a slight tendency to produce *Grandinia* granules. No included crystalline matter. Hyphae very distinct of even diameter $5-6\ \mu$

wide. Basidia with a conspicuous clamp at the base, $3-4 \times 12-14 \mu$. Spores ellipsoid flattened on one side $1.8-2 \times 3-3.5 \mu$.

Specimens examined: Ontario: Temagami, R. Biggs, Univ. of Toronto Herb. numbers 10244, 10246.



FIGS. 21-26. Basidia and spores of *Corticium coronilla* groups I-IV; 21, group I, no. 585; 22, group II, no. 617; 23, group IIIa, no. 773; 24, group IIIb, no. 831; 25, group IIIc, no. 506; 26, group V, no. 647. Magnified $\times 700$.

Group III (b) (FIG. 24)

Fructification pellicular smooth. Edge thinning out but not fibrillose. Subiculum lacking included crystalline matter. Hyphae abundant and distinct, of even diameter $5-6 \mu$ wide. Basidia with a conspicuous clamp at the base usually $4-5 \times 13-15 \mu$. Spores ellipsoid flattened on one side $2-2.5 \times 4-4.5 \mu$.

Specimens examined: Ontario: Toronto, H. S. Jackson, Univ. of Toronto Herb. number 10247.

Group III (c) (FIG. 25)

Fructification pellicular, smooth. Edge distinctly fibrillose. Light brown sandy masses of bulbils associated with the hymenium. Hyphae abundant, distinct and of even diameter $5-7\ \mu$ wide. Basidia conspicuously larger than in other specimens $4.5-6 \times 18-20\ \mu$. Spores ellipsoid, sometimes slightly curved $2.5-3 \times 5-5.5\ \mu$.

Specimens examined: Massachusetts: Medford, Linder, Farlow Herb.

TABLE VIII

CHARACTERS OF SPECIMENS OF *C. coronilla* GROUPS I-IV

| Group Number | Spore Characters | Basidia | Character of Hyphae and Subiculum | General Appearance of Specimen |
|--------------|-------------------------------------------------------------------------|------------------------------------------------|----------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|
| I | $1.8-2 \times 3-4.5\ \mu$ ellipsoid not curved | Variable, most usually $3-4 \times 12-14\ \mu$ | Subiculum with some incrustation, hyphae sometimes distinct $3\ \mu$ | Delicate, coarsely powdery edge indeterminate, with a general tendency to grandinoid granulations |
| II | $1.8-2 \times 3.5-5\ \mu$ ellipsoid curved | Very variable, $3-4 \times 13-20\ \mu$ | Subiculum with conspicuous incrustation. Hyphae $2-5\ \mu$ | Rather thick, edge indeterminate, all specimens with distinct grandinoid granulations |
| IIIa | $1.8-2 \times 3-3.5\ \mu$ ellipsoid flattened on one side | $3-4 \times 12-14\ \mu$ | Subiculum hyphae regular and distinct $5-6\ \mu$. No incrustation | Pellicular with a rhizoidal fibrillose edge |
| IIIb | $2-2.5 \times 4-4.5\ \mu$ ellipsoid flattened on one side | $4-5 \times 13-15\ \mu$ | Subiculum hyphae regular and distinct $5-6\ \mu$. No incrustation | Pellicular. Edge indeterminate |
| IIIc | $2.5-3 \times 5-5.5\ \mu$ ellipsoid curved | $4.5-6 \times 18-20\ \mu$ | Subiculum hyphae regular and distinct $5-6\ \mu$. No incrustation | Pellicular. Edge rhizoidal. Masses of pale brown bulbils found in association |
| IV | $2-3 \times 3.5-4.5\ \mu$ ellipsoid-subglobose flattened on one side | $5.5-6 \times 12-13\ \mu$ | Subiculum hyphae of wide diameter and often irregular $5-6\ \mu$ | Very delicate with no grandinoid granulations. Edge indeterminate |

TABLE IX
CULTURAL CHARACTERS OF *C. coronilla* GROUPS I-IV

| Group Number | Hyphae | Heterothallism | Fructification | Growth and General Appearance |
|--------------|------------------------------------------------------|----------------|-------------------------------------------|----------------------------------------------------------------------------------------------------------------------|
| I | Usually agglutinated and indistinct | Bipolar | None | Growth rapid submerged, no microscopic distinguishing characters |
| II | Often agglutinated and indistinct up to 5 or 6 μ | Homothallic | In both monospore and poly-spore cultures | Growth rapid and always some aerial mycelium. Several specimens produce bulbil-like cells |
| IIIa | Distinct 5-7 μ | Tetrapolar | None | Growth mediumly rapid with conspicuous aerial rhizoidal strands. Bulbils and oidia produced |
| IIIb | Distinct 5-7 μ | Tetrapolar | None | Growth rapid and lacking rhizoidal strands. Aerial mycelium cottony. Bulbils and oidia produced |
| IIIc | Distinct 5-7 μ | ? | None | Growth medium rapid with conspicuous aerial rhizoidal strands. Bulbils and oidia produced |
| IV | Distinct 5-7 μ | Heterothallic | None | Growth very slow and almost entirely submerged. Conspicuous separable spherical cells produced apically or in chains |

Group IV (FIG. 26)

Fructification very delicate, rather coarsely powdery with no tendency to produce *Grandinia* granules. Edge indeterminate. Subiculum scanty, lacking incrustation. Hyphae usually distinct, rather irregular, 5-6 μ in diameter with occasional swellings up to 8 or 9 μ . Basidia shorter and broader than in the other groups, 5.5-6 \times 12-13 μ . Spores short ellipsoid to subglobose, flattened on one side 2-3 \times 3.5-4.5 μ .

Specimens examined: Ontario: Temagami, R. Biggs, Univ. of Toronto Herb. numbers 10248, 10249, 10250, 10251, 10252, 10253, 10254.

From these descriptions it is obvious that distinct, though minute

differences can be distinguished between the specimens of the fungi belonging to each of the four cultural groups.

From tables VIII and IV the general characters of the specimens can be correlated with those of the corresponding cultures. It is interesting to note that the characters of the specimens are often comparable to those of the cultures. For example, the fungi in group IV develop delicate fructifications in nature and grow poorly in culture. The fungi in group IIIa and c, which develop a rhizoidal growth in culture, also show a fibrillose edge in nature. The fungi in which the hyphae become agglutinated in culture often show indistinct hyphae in nature, etc.

DISCUSSION

The problems which are most immediately suggested by these results are: (1) Do the four groups described represent the only growth types within the species? (2) Do these growth types represent distinct species, and if so do they correspond with any of the hitherto described species?

To consider the first problem. It is quite certain that the growth varieties described are but four of an indefinite number of similar varieties.

In the first place, cultural studies with an additional specimen, no. 519, have shown that this is probably distinct. The growth on agar is slow, submerged and different from that in the other groups. Some relationship to group III is possibly indicated by the occurrence of bulbil-like masses in the submerged mycelium. The monosporous cultures from this strain failed to pair with those of any of the other groups. An examination of the original specimen showed that this also differs considerably from the specimens of the other groups. The general appearance is extremely delicate and the internal structure agglutinated and indistinct. This specimen was not included as group V of *C. coronilla* for the sole reason that it was considered unsatisfactory to base any general conclusions on a single specimen.

In addition to the culture no. 519, a number of polysporous cultures were obtained from additional specimens whose growth on agar is comparable to that of the fungi in group I. The growth

characters of this group are, however, essentially negative and in the absence of pairing reactions it would be impossible to be certain of their relationships. The specimens corresponding to these additional polysporous cultures show a wide range in general appearance and spore size and shape. In the fungi definitely assigned to group I both spore size and shape are relatively constant. If these results are of any value, the range in spore characters among these additional specimens must indicate the occurrence of yet other groups.

Again, among the specimens included in the species *C. coronilla* v. Höhn. & Lit. in the University of Toronto Herbarium are a number with a very distinct appearance and structure. These correspond with the general description of the species but could not be referred to any of the four described groups.

This evidence indicates that *Corticium coronilla* v. Höhn. & Lit., considered in the widest sense is a very complex entity made up of innumerable different and more or less well defined strains.

To consider next the significance of these strains. In a group of simple organisms the characters available for the determination of relationships are necessarily limited. If this fact is taken into account, it will be realized that the four strains of *C. coronilla* described differ from each other in profound and fundamental characters. The occurrence of such differences between related fungi must indicate that they represent distinct species. However, were these groups recognized as distinct, the practical difficulties of species identification would be considerable. Further, it has been shown that this complex comprises many groups other than those described and clearly the creation of new names for these four alone would be of little value. Finally, none of the strains described corresponds at all closely with any of the previously recognized species. The species *Grandinia Brinkmannii* (Bres.) Bourd. & Galz. would appear to be of particularly little value as a *Grandinia* tendency is present in more than one of the groups described.

It is therefore proposed, for the present, to include all the variations within the species *Corticium coronilla* v. Höhn. & Lit., recognizing that this is a complex entity.

From this study it is evident that when specimens referred to a single species show a wide range of morphological variation one may suspect that this species is a collective entity. These aggregate species are convenient provisional groups made up of innumerable more or less constant genetic strains. Such collective species can have no fundamental systematic importance. It should therefore be realized that without a careful cultural analysis, it is never permissible to regard wide morphological variations within a species as the expression of chance environmental fluctuations.

SUMMARY

Specific limits in the Thelephoraceae are not always clear and the characterization of the simpler species is often inexact. Published descriptions are frequently inadequate and many of the distinguishing features stressed are found to be inconstant. On account of this confusion it was thought that cultural studies in this group might provide additional criteria for the delimitation of the simpler species.

Sets of monosporous cultures were obtained from a range of specimens included in the variable species *Corticium coronilla* v. Höhn. & Lits. Among these cultures four totally distinct cultural groups could be recognized. These groups differed from each other in general growth, presence or absence of asexual reproductive structures, ability to produce basidia in culture and type of heterothallism. The specimens associated with each of the four groups were uniform and minute consistent morphological differences occurred between the members of the different groups. The fundamental differences between these groups can only indicate that they represent distinct species.

A study of additional specimens and cultures indicated that a further study would disclose many other groups in addition to the four described. In view of the very complex nature of the species it was considered best to include all the four types in the collective species *Corticium coronilla* v. Höhn. & Lit. It should, however, be realised that this is genetically a very complex entity.

LITERATURE CITED

- Bourdot, H., & Galzin, A. 1927. Hymenomycetes de France.
- Burt, Edward Angus. 1926. The Thelephoraceae of North America. XV. *Corticium*. Ann. Mo. Bot. Gard. 13: 173-354.
- Lyman, G. R. 1907. Culture studies on polymorphism of Hymenomycetes. Proc. Bost. Soc. Nat. Hist. 33: 125-210.
- Mounce, Irene. 1921. Homothallism and the production of fruit-bodies on monosporous mycelia in the genus *Coprinus*. Trans. Brit. Myc. Soc. 7: 198-217.
- Quintanilha, A. 1935. Cytologie et Genetique de la sexualite chez les Hymenomycetes. Bol. Soc. Brot. II. 10: 1-48.
- Rogers, Donald P. 1935. Notes on the lower Basidiomycetes. Univ. Iowa Studies 17: 1-43.

THE PERITHECIAL CAVITY FORMATION IN A LEPTOSPHERIA ON OPUNTIA

B. O. DODGE

(WITH 2 FIGURES)

The formation of the gill cavities in mushrooms has been the subject of much study and dispute during the last fifty years and there is still disagreement as to the initial processes in cavity formation. On the other hand very few studies have been made in following through the processes by which the central cavities in pycnidia and ascocarps have been developed. Cavity formation in three different types of pycnidia has been described by the writer (1923). In *Phyllostictina carpogena* the cavity is largely lysigenetic; in that of *Sclerotiopsis concava* (pycnidial stage of *Pezizella Lythri*) it is about equally lysigenetic and schizogenetic, while the cavity in both the pycnidium and the ascocarp of *Schizoparme* is largely schizogenetic, and the two fruiting structures are also very much alike morphologically. Other literature on cavity formation is cited in the paper referred to.

One does not usually expect to find old herbarium material to be of much value for studies of this sort, but a specimen of *Hendersonia Opuntiae* collected by Wolf (1912) and deposited in the herbarium of The New York Botanical Garden proves to be rather an exception in this respect. Wolf has described, the "Sun scald disease," caused by this species of *Hendersonia*. The reader is referred to his paper for information regarding the morphology of the pycnidial stage as he found it on the prickly pear, *Opuntia Lindheimeri*.

The specimen in our herbarium, however, is interesting in that along with many pycnidia of *Hendersonia*, there are also many ascocarps of a fungus which would ordinarily be classed as a *Leptosphaeria*. It is with the organization of the cavity of these ascocarps that the present paper is mainly concerned. As it is

evidently not *L. sicula* reported on *Opuntia*, it will first be described and given a name for identification purposes.

Leptosphaeria Opuntiae sp. nov.

Ascomcarps separate, thickly scattered over the segment, imbedded, ostiolate, with a thickened cap or clypeus of dark colored buffer tissue about $200\ \mu$ in diam.; perithecial wall $15\text{--}20\ \mu$ thick. The cavity as seen in sections of dried material is about $130\text{--}170 \times 90\ \mu$, and is in young fruit bodies filled with vertically oriented septate hyphae attached to the wall at the top as well as the bottom of the cavity, probably constituting the first "paraphyses"; asci cylindrical, rather thick-walled $70\text{--}90 \times 12\text{--}15\ \mu$, 8 spored; spores more commonly uniseriate, occasionally partly biseriate, olivaceous brown, 3-septate, $17\text{--}20 \times 5\text{--}6.5\ \mu$, end cells somewhat smaller. the second and larger cells sometimes with a longitudinal wall.

Perithiciis c. $150\text{--}300\ \mu$ diam.; ascis cylindricis, $70\text{--}90 \times 12\text{--}15\ \mu$ octosporis; sporis olivaceo-brunneis 3-septatis, $17\text{--}20 \times 5\text{--}6.5\ \mu$.

On *Opuntia Lindheimeri* Austin, Texas, associated with *Hendersonia Opuntiae* of Wolf in the herbarium of The New York Botanical Garden.

Brefeld (Unters. 10: pl. 8, fig. 1) figures an ascus of what he calls *Pleomassaria rhodostoma*. Here the second cell in some of the ascospores has a longitudinal wall. Berlese shows an ascus of *Pleospora leptosphaerioides* with the same type of ascospores. In whatever genus we may place this *Opuntia* fungus we are certain someone will soon place it in another genus and make a new combination. In this group of fungi not only are generic distinctions a matter of opinion, but specific differences are often not very distinctive. The particular genus or species of host attacked may be considered of sufficient importance to be diagnostic. Dr. C. L. Shear has suggested to me that this ascocarp has the structure such as von Höhnelt made the basis for his group Pseudosphaeriaceae to which *Botryosphaeria* and *Pleospora* belong.

According to Wolf the vegetative mycelium of *Hendersonia Opuntiae* is entirely within the epidermal tissue system. As a result of the presence of the fungus nearby, a suberized callus is formed below. The parasite is therefore not deep-seated. He says that the pycnidia are either above the crystal-bearing hypo-

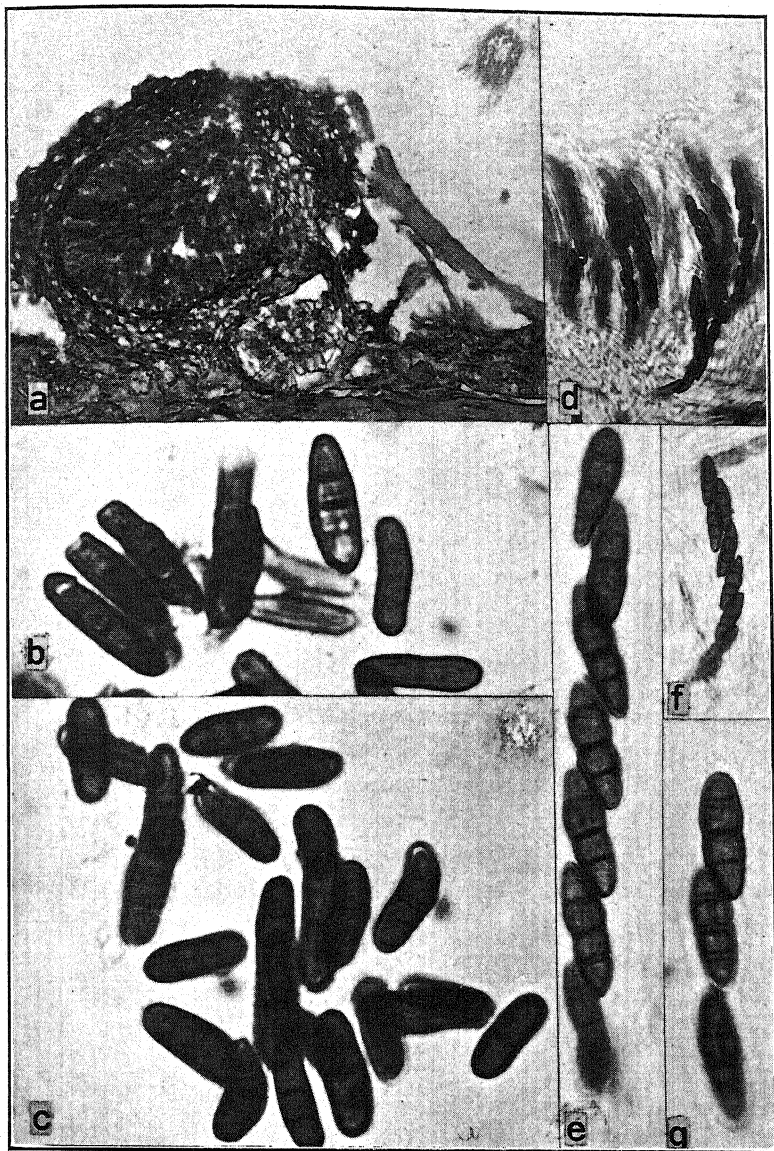


FIG. 1. *Hendersonia* and *Leptosphaeria*.

dermal layer or are developed beneath it. Sections of Wolf's specimen (FIG. 1, a) in our own herbarium prove that his statements in this regard are correct, as are also his descriptions of

the wall and thickening around the ostiole. It is difficult to reconcile his description and illustrations of conidia (FIG. 7) with the conidia found in his material, where they are not deeply constricted at the septa and they are certainly not often six times as long as they are wide, $24-30 \times 4-5 \mu$, as he says. We measured some of the conidia and found them somewhat shorter, $17-21 \times 4.5-5 \mu$. Our mounts also show that the spores may be slightly curved, as Ellis pointed out. Wolf's conidia as shown in his fig. 7 look much like the ascospores of the *Leptosphaeria* associated with the pycnidia in his specimen.

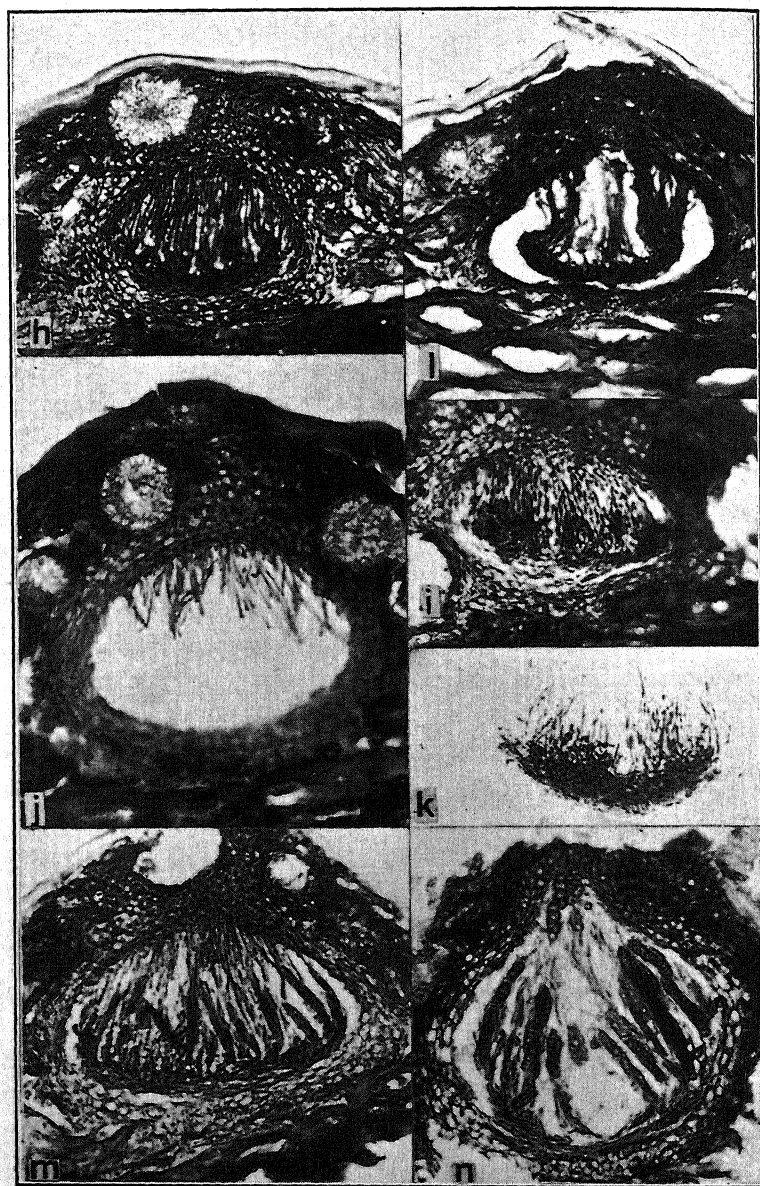
Wolf's specimen in our herbarium shows a great many black fruiting bodies distributed over both surfaces of the segment. There are numerous typical *Hendersonia* pycnidia, especially on the one side, but scattered among them there are also numerous ascocarps. On the other side of the segment one finds here and there good pycnidia, but more frequently the fruiting bodies of an ascomycete resembling a *Leptosphaeria*, or as some may prefer to call it a *Clypeosphaeria* because of the thickening around the ostiole (FIG. 1, a). Wolf does not mention seeing this ascocarpic form.

On the same sheet is a specimen labeled "*Hendersonia Opuntiae* E. & E. On *Opuntia Ficus Indicus*, Alabama (Carson 592) Herb. Ellis." We were unable to find any pycnidia in the numerous mounts made from this material, but in every mount one could find fragments of asci with brown, 3-septate spores constricted at the septa (FIG. 2, n). Some of this material was imbedded and sectioned. The slides all showed ascocarps but no pycnidia. As the specimen is rather fragmentary it was not considered advisable to search further for pycnidia. Ellis must have seen true *Hendersonia* pycnidia, judging from his description. Whether or not this specimen constitutes the type of the species is not known for certain, but Wolf (1912) did see what was claimed to be the type, and says that the pycnidial characters of his material agreed with those of the type. The fact that there is an abundance of ascocarps in the Ellis material as well as in the Wolf specimen, collected far apart, should lead one to consider the possibility of a connection between the *Leptosphaeria* and the *Hendersonia* spore forms.

There are a great many cases where the conidia of an ascomycete resemble very greatly the ascospores of the species, and there are also other species where the pycnidial fruit body resembles the ascocarpic fruit body in its organization. The Wolf material is so abundant that one can study the ascocarps in great detail. They are perhaps more deeply imbedded than the pycnidia, but one cannot tell them apart with certainty until they are crushed in his mounts.

As stated in the description the asci are about $13-15 \times 85-90 \mu$ and have rather persistent walls. The ascospores are either uniseriate or partly biseriate. The spores are brown, 3-septate and constricted at the septa, tapering somewhat. The second cell which is usually somewhat larger than the others is rarely divided by a longitudinal wall. Some would insist that this character would take the species out of the genus *Leptosphaeria*. It is certainly not a *Sporormia*, although in the organization of the cavity of the ascocarp it is like "*S. leporina*" described by Arnold (1928). Paraphyses (?) are numerous and threadlike. The Ellis material corresponds to the ascocarpic form on the Wolf specimen. The ascospores sometimes show a layer of what may be a very thin transparent substance surrounding them, provided one cuts down the light a great deal. No mucous sheath, such as one expects to see in a *Sporormia*, is present. Berlese shows a layer of transparent substance surrounding ascospores of certain species of *Leptosphaeria*.

One could follow the development of the perithecial cavity very well in this dried material. As the ascocarps begin to enlarge certain cells at the center elongate side by side and divide as the outer layers of the fruit body increase in circumference. The central cells elongate more and more, maintaining their attachment to the inner wall cells above and below (FIG. 2, *h, i*). Finally there appears to be some disintegration of the streamer-like vertical hyphae and some of them disappear as the young ascogenous hyphae begin to grow. The threads that persist and that may be seen in crushed mounts would naturally be referred to as paraphyses. One might be misled by the appearance of the disorganizing threads (FIG. 2, *i*) into thinking that septate conidia are arising in chains and that the young fruit body is really a pyc-

FIG. 2. *Leptosphaeria*.

nidium instead of an ascocarp. We have not seen any young pycnidia in this material so that we cannot say how a *Hendersonia* cavity is formed. But there is no doubt that the young fruiting bodies that we see are young ascocarps, as many intermediary stages have been found.

Arnold (1928) has described the origin of the perithecial cavity in "*Sporormia leporina*." His figures 15-21 represent very well what our sections of the cactus fungus give us (FIG. 2, *h, i*). He says, however: "When the larger perithecia are dissected with needles under a dissecting microscope it is possible to remove the mass of large cells from the cavity still attached to the lower ends of the vertical hyphae which in turn tend to break loose from the top of the cavity with frayed ends. . . . No true paraphyses were observed."

In our material one can prove that the vertically oriented hyphae are attached to the inner wall cells *below* as well as above. They are in a sense intercalary elements which increase in length with the increase in periphery of the ascocarp. These threads undergo a certain amount of disorganization as the cavity enlarges.

It would be strange to find ascogenous hyphae and asci swinging from the lower ends of down growing hyphae in a cavity where they would hang like a swinging basket. There is no question that the ascogenous hyphae and asci are firmly attached to the wall of fertile tissue below (FIG. 2, *j*). The ascogenous elements arise from the layer of active tissue below, so that young asci crowd up between the vertical space-making hyphae. Clements and Shear (1931) use the term paraphysoids for plates of cellular tissue between asci, which are more or less like paraphyses. Crushed mounts which include mature asci with spores, show what look to be true paraphyses in our material (FIG. 1, *d*), but some of these threads no doubt represent the original intercalary space-making elements.

Emmons and Dodge (1931) show that in species of *Microascus* the ascogonium from which ascogenous hyphae are developing is high up in the ascocarp, just beneath the ostiole which is beginning to form. Space-making hyphae have already arisen from the walls of the perithecial cavity, and as this increases in size, the threads grow mostly upward and inward, although some of them grow

down from above. If these paraphysis-like hyphae are ever originally intercalary, the ends attached to opposite walls, the connection above must break rather early.

The perithecial cavity of *Neurospora* (Shear & Dodge 1927, pl. 2, E) is filled with upward and inward growing hyphal elements, "paraphysoids." These are most clearly visible about the time asci begin to grow up from below, but they soon disappear, providing in their disorganization nourishment for the forthcoming asci. Their primary function is space making, however. In such forms paraphyses or paraphysoids and ascogenous cells may develop from similar elements. Sexuality in such forms may well be confined to nuclear fusion in the young asci. In certain ascomycetes such as *Ascobolus* and *Pyronema*, ascocarps have their origin in special primordia from certain cells of which ascogenous elements grow out, while paraphyses and other sterile tissues develop from basal cells or adjacent hyphal branches.

SUMMARY

A species of *Leptosphaeria* here described as *L. Opuntiae* is associated with *Hendersonia Opuntiae* Ellis & Ev. on segments of *O. Lindheimeri* from Texas collected by Wolf and deposited in The New York Botanical Garden. A specimen labeled "*Hendersonia Opuntiae* E. & E." from Alabama in the Ellis Herbarium also shows numbers of ascocarps of the same *Leptosphaeria*. The ascocarpic and pycnidial fruit bodies develop clypeate buffer tissue about the ostiolar region. Ascospores and conidia are brown and 3-septate. The association and similarities in morphology suggest that possibly these two forms belong to the same fungus. The connection would have to be proved by culture work.

The perithecial cavity develops largely through the differential growth of the peripheral tissues as a wall while the cells at the center elongate vertically by adding intercalary cells so that one sees streamers of hyphae extending across the cavity and attached to the wall cells above and below. Ascogenous elements arise from the fertile tissue at the base and grow up between the disorganizing vertically growing space-making hyphae. These ascogenous elements do not arise from the lower ends of free swinging vertically

downward growing hyphae as claimed for *Sporormia leporina* by Arnold. Otherwise cavity formation in this *Leptosphaeria* and the *Sporormia* seems to be identical.

The writer is indebted to Mr. Frank Paladino for the preparation of slides from herbarium material for this study.

THE NEW YORK BOTANICAL GARDEN

LITERATURE CITED

- Arnold, C. 1928. The development of the perithecium and sperm(o)-gonium of *Sporormia leporina* Niessl. Am. Jour. Bot. 15: 241-244, pl. 15, 16.
- Clements, E. F. & C. L. Shear. 1931. The genera of fungi.
- Dodge, B. O. 1923. Origins of the central and ostiolate cavities in pycnidia of certain fungous parasites of fruit. Jour. Agr. Res. 23: 745-759, pl. 1-6.
- Emmons, C. W. & B. O. Dodge. 1931. Ascocarpic stage of species of *Scopulariopsis*. Mycologia 23: 313-331, pl. 25-28.
- Shear, C. L. & B. O. Dodge. 1927. Life histories and heterothallism of the red bread-mold fungi of the *Monilia sitophila* group. Jour. Agr. Res. 34: 1019-1042, pl. 1-4.
- Wolf, F. A. 1912. Some fungous diseases of the prickly pear, *Opuntia Lindheimeri* Englm. Ann. Myc. 10: 113-134, pl. 1-3, figs. 1-8.

EXPLANATION OF FIGURES

Fig. 1, *a*. Section of pycnidium of *Hendersonia Opuntiae* Ellis & Ev from the Wolf specimen in the herbarium of The New York Botanical Garden. *b*, *c*. Conidia of the *Hendersonia* showing three septa and rounded ends; some of the conidia are slightly curved as noted by Ellis. *d*. Asci from crushed mount of *Leptosphaeria Opuntiae* showing asci with "paraphyses" or space-making hyphae. *e*. Spores from an ascus of *Leptosphaeria* more highly magnified, the same magnification as the conidia shown in *b*, *c*. *f*. Another ascus less highly magnified. *g*. Three ascospores each showing a longitudinal wall in the second cell.

Fig. 2, *h*, *i*. Sections of young ascocarps of *Leptosphaeria Opuntiae* showing vertically oriented space-making hyphae, which in *i* have begun to disorganize. *j*, *k*. Section of an ascocarp showing particularly that the space-making hyphae are attached at their upper ends to the inner cells of the perithecial wall. Three large calcium oxalate crystals which develop in the hypodermal layer are visible. The lower ends of these internal hyphae with their attachments to the cells of the bottom of the cavity are shown in fig. *k*, which is a fragment of the section shown in *j*, dislodged by rough treatment so that one can see that these vertical hyphae are also attached to the cells at the bottom of the cavity. *l*. Section of a young ascocarp showing how, because of the shrinkage due to the original drying out process or to

the treatment applied as this dried specimen was imbedded, several layers of cells from the wall of the perithecium have become torn away. The attachments of the vertical hyphae at the top as well as at the bottom of the cavity persist. The ostiole is just beginning to form through lysigenetic processes. Naturally the vertical hyphae attached to this ostiolar tissue would disappear early as shown in the figure, but the layers of fertile tissue at the bottom are not at all affected. *m.* Section of an ascocarp showing rather young asci which are pushing up between the vertically oriented hyphae. These hyphae when seen in crushed mounts would certainly be referred to as paraphyses. Old perithecia might not show such hyphae. *n.* Section of an ascocarp from the Ellis specimen No. 592 labeled "*Hendersonia Opuntiae* E. & E." referred to in the text.

NOTES ON THE SYNONYMY OF FRENCH AND AMERICAN AGARICS—I

MARCEL JOSSERAND AND ALEXANDER H. SMITH

It is generally admitted that confused synonymy is the plague of contemporary Mycology, and chiefly responsible for the babelian state of this branch of natural history: each one speaks a language different from that of his neighbor.

In his inaugural address at the 1934 session of the Société Mycologique de France, Dr. R. Maire remarked that no work was more pressing than the unification of local nomenclature. The first phase of this work, the unification within a country, is already well advanced. A second phase comprises the establishment of equivalences between neighboring countries. This has been started in Europe, notably between France and Switzerland, England, Belgium, etc. Concerning European and American synonyms, continued Dr. Maire, we face a much more delicate problem for one encounters the existence of *geographic races* which complicate the establishment of synonyms between the fungi of the old world and the new.

Lange (9) in his comments on agarics in North America discussed briefly the existence of "parallel species" in North America and Europe. He also reemphasized the view which many American mycologists have long held, that, in reality, the North American fungous flora and that of Europe are characterized by the presence of a larger number of species in common than the published floras indicate. The task of accurately determining the true synonyms and the recognition of "parallel species" is however a very delicate one, and involves a careful study of the variations of each species not only in each country but in various regions of the same country as well as in the same locality over a period of several seasons. The coexistence of a striking character in a European and an American species does not suffice to justify the identification of the one with the other. In order to pronounce

them synonyms it is necessary to have a perfect superposition of the two series of characters. If there is the slightest doubt, it appears to be wiser not to place them in synonymy for we believe that it is incomparably less serious and less confusing to permit the existence of two names for the same plant than to designate a mixture of two species with a single name.

This is the principle which is guiding us in establishing the following synonyms. Rather than present a long but uncertain list, we have preferred to restrain ourselves to a discussion of ten binomials of which the equivalences have been carefully verified by exchanges of descriptions, comments, photographs, dried specimens and even in one case fresh specimens.

COLLYBIA MYRIADOPHYLLA (Peck) Sacc.: COLLYBIA LILACEA
Quélet

In the region of Lyon the senior author has had the good fortune on several occasions to collect a fungus which is very rare in France, *Collybia lilacea* Quél. Apparently it has not been rediscovered in France since it was described sixty years ago, and has remained poorly known partly because of its rarity and partly because Konrad (7) and later Konrad and Maublanc (8) published under the name "*Collybia lilacea* Quél. forme robuste" a species not at all similar to that of Quélet. The specimens found near Lyon correspond well to the species of Quélet. This was evident not only from the description by Quélet but also from a water color which was copied directly from the original water color of Quélet and sent to the senior author by Mr. M. F. Bataille who possesses many of Quélet's original paintings and who is well acquainted with the species studied by the famous French mycologist.

This *Collybia* (which might be better placed in the genus *Marasmius*) is characterized by exceptionally crowded amethyst colored gills, by minute spores and by an exceptional anatomical structure: large plates of incrusting pigment on the hyphae of the covering of the pileus and stipe as well as on the cheilocystidia.

Among the American *Collybias* is found *C. myriadophylla* (Peck) Sacc. which also has violet colored, very crowded gills

and very small spores. The senior author suspected the synonymy, but was blocked by several discrepancies between the characters given by the Americans for *C. myriadophylla* and those which were discovered in the *Collybia lilacea* of France. In particular neither Peck (12) nor Murrill (10) mentioned cystidia. Kauffman (5) specifically stated "cystidia none." As *C. lilacea* in France possessed numerous cystidia, verification was necessary. The junior author therefore sent material from his own and from Kauffman's collections to the senior author who was able to ascertain, contrary to the indications of the describers, that the species possessed numerous cheilocystidia identical with those of *C. lilacea* and furnished with the same incrustation. The other micro-characteristics coincided in an equally perfect manner and no doubt remained. It was then possible for the senior author to state (3) the identity of the two plants in a note where he gave a detailed description of the species, scarcely rare in the United States but exceptionally rare in France.

Concerning the name, the rule of priority favors that of Peck who published *Agaricus myriadophyllus* in 1873 (12) instead of that of Quélet who published *Collybia lilacea* two years later in 1875 (16). The latter is therefore a synonym.

OMPHALIA GRACILIS Quélet: MYCENA IMMACULATA (Peck)
Sacc.

It is very hard to be sure that the plant that European mycologists today call *Omphalia gracilis* is indeed the fungus described under this name in 1880 by Quélet. In truth, *O. gracilis* was at first a "mixtum compositum" in Quélet's own mind and contained two or three species. However, it is very probable that the true *O. gracilis* corresponds to the conception of Quélet in his later years. In any case this concept of the species has been definitely established by Konrad & Maublanc (8) and secondly by the senior author (1).

This white *Omphalia* is well defined by its habit of growing near *Abies* (or *Picea* in North America), by its subcylindric spores and by the absence of long hairs on the pileus: this last character, joined with several others, distinguishes it from *Omphalia angustispora* Josserand (1) which also has elongated narrow spores.

In 1935 the junior author (20) stated that *Mycena immaculata* was without doubt a synonym of *O. gracilis*. Later we proceeded with a comparison of drawings, photographs, descriptions and an anatomical study of dried specimens which permitted us to confirm the suggested synonymy.

Concerning the priority of the name, Quélet described *O. gracilis* in 1880 whereas Peck did not describe *Agaricus immaculatus* until 1885 (14). Thus the latter specific name must be placed in synonymy.

OMPHALIA MARGINELLA (Pers.) Joss. & Maire: OMPHALIA
RUGOSODISCA Peck

In 1931 the senior author in collaboration with Dr. R. Maire (4) published a study on *Agaricus marginellus* Persoon, a species poorly interpreted by many authors and of which it was expedient to untangle the synonymy. A description and drawings of the French collections accompanied the account of this study. As a result of it, Smith suggested that *Omphalia rugosodisca* Peck was very similar to *O. marginella*. Not only did the ensemble of the general characters coincide, but the same remarkable exudation of a colorless juice was found in both species.

Two slight differences seemed from the first to separate them. *A*, the stipe of *O. rugosodisca* is said to be glabrous. However, this is an error in description, for specimens collected by the junior author (who has studied Peck's type) were densely pruinose like those of *O. marginella* of Europe. *B*, the edge of the gills is always bordered with pale-brown in *O. marginella* whereas in *O. rugosodisca* the gill edges are practically colorless. The microscopic examination of American specimens prepared by Smith and sent to Jossierand cleared up this discrepancy. The edges of the gills of *O. marginella* are composed of numerous cheilocystidia. Almost all are filled with a brown pigment in the vacuole; those which are uncolored are very rare. The pigmented cells cause the brown color of the gill edge. In *O. rugosodisca* one finds the same cheilocystidia as numerous as in the French specimens, but the formula is reversed; those which possess a vacuolar pigment are very rare, the greater portion being colorless and consequently

the gill edge is also colorless or nearly so. The discrepancy is therefore not fundamental but purely quantitative.

In addition to the above, the specimens of *O. rugosodisca* have not only the same spores, the same cheilocystidia and the same caulocystidia, but also the same lactifers, and in particular the same unusual covering of the pileus as found in *O. marginella*. This covering of the pileus is unique or at least rare in *Omphalia*. The hyphae which form it are neither appressed nor upright in a hymeniform layer but rather obliquely and irregularly arranged among themselves. It is this disposition as well as the form of the hyphae which give the cap its particular micaceous, pseudo-pruinose aspect. We say "pseudo" because the pruinosity is not made up in reality of any definite hairs. One finds the same hyphal covering in *Naucoria effugiens* and in another *Naucoria* probably undescribed which presents precisely the same aspect.

The distinctive anatomy of *O. marginella* has confirmed the supposition of Smith and established its identity with *O. rugosodisca*. *O. rugosodisca* should fall into synonymy unless one prefers to use it as a varietal designation for fruit-bodies having non-bordered lamellae. This should then be written to conform with the rules of nomenclature as *Omphalia marginella* (Pers.) Joss. & Maire var. *rugosodisca* (Peck) comb. nov. Both the species and the variety have been found in the United States, Smith (21).

PANELLUS MITIS (Pers.) Singer: PANUS BACILLISPORUS
Kauffman

Agaricus mitis, long called *Pleurotus mitis*, but which now should be called *Panellus mitis* since the very legitimate division of the heterogeneous genus *Pleurotus* into several distinct genera, is a species very abundant in France, as well as in all of Europe where it grows in dense colonies on branches of dead conifers.

It is recognized by its ivory-white tint becoming slightly russet in the adults, its tenacity, its gelatinous trama, its mild taste and by its narrowly allantoid spores.

The senior author having read the characters given by Kauffman (6) for his *Panus bacillisporus* found that they coincided perfectly with those of the European *P. mitis* and was of the impres-

sion that the two species were the same. This suspicion was substantiated by the fact that *P. mitis* seemed to be lacking in the flora of North America. Upon his suggestion, the junior author examined authentic material of *P. bacillisporus*, compared dried specimens of both species, and found them to be identical. He also examined photographs of the European *P. mitis*. Finally to eliminate all doubt, Jossierand had the temerity to send Smith living specimens of *P. mitis* collected near Lyon. Sent in a metallic box on their woody substratum, they crossed the ocean without damage and arrived still fresh in Ann Arbor where Smith was able to reaffirm the identity of *P. mitis* and *P. bacillisporus*. This is without doubt the first time that Agarics have been sent in the living state from one side of the Atlantic to the other.

Agaricus mitis being the older name, *Panus bacillisporus* falls into synonymy.

PHOLIOTA ALBOCRENULATA Peck: PHOLIOTA FUSCA Quélet

This species is not rare in the United States but is extremely rare in France and Europe where it has been reported only three times, twice in France and once in the Carpathian Mts.

The senior author has seen material collected in the region of Lyon, and has been able to study it in detail. Its characters correspond exactly with those given by Overholts (11) for *P. albo-crenulata* Peck and it is under this name that our colleague Pouchet (15), who saw it at the same time the senior author saw the lyonnaise specimens, has given a detailed description of it.

Among the characters of the species should be emphasized the viscid caps of a particular brown and ornamented with appressed scales, the tenacious and elastic cuticle, the large fusoid almond shaped spores with a thick but smooth membrane, and finally the abundant cheilocystidia which form an enlargement of the gill edge, and which macroscopically cause the broad white gill margins which give the fungus its name.

After studying the specimens from Lyon, the senior author suspected that this fungus was *P. fusca* Quélet, a very rare French species not authentically reported since its description. However, the diagnosis of Quélet is too brief to allow one to decide this

question with certainty. Fortunately Mr. M. F. Bataille, a student of Quélet's and possessor of many of Quélet's documents, presented Josserand with a copy of a painting which was executed directly and very carefully from the water color painted by Quélet himself illustrating his *P. fusca*. This water color represents perfectly the aspect of *P. albocrenulata* collected at Lyon and enabled the senior author to publish a note (2) stating that *Pholiota fusca* is synonymous with *Pholiota albocrenulata* Peck. Harper had already suggested this relationship.

Concerning the priority of the name, it is apparent that that of Peck was published in 1873 whereas Quélet did not describe *P. fusca* until three years later in 1876 (17).

SUMMARY

After exchanging descriptions, photographs, dried specimens and in one case fresh specimens, the writers propose the following synonyms.

1. *Collybia myriadophylla* (Peck) Sacc. (= *Collybia lilacea* Quélet)
2. *Omphalia gracilis* Quélet (= *Mycena immaculata* (Peck) Sacc.)
3. *Omphalia marginella* (Pers.) Joss. & Maire (= *Omphalia rugosodisca* Peck)

If one prefers to conserve a name by which to designate the American form with nonbordered gill edges, the combination *O. marginella* (Pers.) Joss. & Maire var. *rugosodisca* (Peck) Smith & Joss. should be used.

4. *Panellus mitis* (Pers.) Singer (= *Panus bacillisporus* Kauff.)
5. *Pholiota albocrenulata* Peck (= *Pholiota fusca* Quélet)

LYON—ANN ARBOR

LITERATURE CITED

1. Josserand, Marcel. Description de quelques Omphales blanches. Ann. Soc. Linn. Lyon 80: 77-96. 1937.
2. ——. A propos de l'existence en Europe de *Pholiota albocrenulata* Pk. Rev. Myc. 10: 18-19. 1937.

3. —. Notes critiques sur quelques champignons de la region lyonnaise, 2^{eme} Serie. Bull. Soc. Myc. Fr. 53: —. 1937.
4. Jossierand, Marcel & R. Maire. Sur l'*Omphalia marginella* (Pers.) Jossierand & Maire (*Omphalia marginella* Quélet.). Bull. Soc. Linn. 10: 115-119. 1931.
5. Kauffman, C. H. The Agaricaceae of Michigan. 1918.
6. —. The fungous flora of the Siskiyou Mountains in southern Oregon. Papers Mich. Acad. 11: 151-209. 1930.
7. Konrad, P. Notes critiques sur quelques champignons du Jura. Bull. Soc. Myc. Fr. 41: 33-70. 1925.
8. Konrad, P. & A. Maublanc. Icones selectae fungorum, Fasc. I and VII, 1925 and 1932.
9. Lange, Jakob E. Mycofloristic impressions of a European mycologist in America. Mycologia 26: 1-12. 1934.
10. Murrill, W. A. *Gymnopus*. North America 9 (5): 352-376. 1916.
11. Overholts, L. O. A monograph of the genus *Pholiota* in the United States. Ann. Mo. Bot. Garden 14: 87-210. 1927.
12. Peck, C. H. Description of new species of Fungi. Bull. Soc. Nat. Sci. Buffalo 1: 41-72. 1873.
13. —. 26th report N. Y. State Museum, p. 55. 1874.
14. —. 38th report N. Y. State Museum, p. 84. 1885.
15. Pouchet, A. *Pholiota albocrenulata* Pk. Ann. Soc. Linn. Lyon 78: 101-104. 1934.
16. Quélet, L. Champignons du Jura & des Vosges, 1869-1875.
17. —. 4^{eme} suppl. a Champignons du Jura et des Vosges, 1876.
18. —. 10-suppl. a Champignons du Jura et des Vosges, 1880.
19. —. Flore Mycologique de la France. 1888.
20. Smith, Alexander H. Unusual agarics from Michigan. III. Papers Mich. Acad. 21: 147-161. 1936.
21. —. Unusual agarics from Western United States. Bull. Torrey Club, 64: —. 1937.

CORYNEUM MICROSTICTUM ON ROSE FROM OREGON

ANNA E. JENKINS

(WITH 2 FIGURES)

INTRODUCTION

In reporting the occurrence in the United States of *Cryptosporium minimum* Laubert, which causes a canker of roses (*Rosa*), it was mentioned (4) that on the diseased canes from Oregon¹ were cankers caused by *Coryneum microstictum* Berk. & Br. Only the *Coryneum* canker had been present on diseased tea roses received from the same source a few weeks earlier. It appeared that the fungus had not previously been recorded from Oregon, and it was considered desirable to compare it with the species from elsewhere. An isolation was made, and early in 1934, the fungus was compared with *C. microstictum* from the eastern part of the United States, Canada, and England. Isolations of *C. microstictum* var. *Mali* Kidd and *C. Beyerinckii* Oud. were included in the cultural comparisons.

HISTORICAL

The most extensive discussion of *Coryneum microstictum* on rose appears to be that by Beauverie (1) in 1912, in connection with his diagnosis of a rose canker as due to this fungus. At that time he commented upon the paucity of the literature on this subject, and except for occasional records of the fungus in one country or another little has since been published concerning it. *Coryneum microstictum* is not indicated as occurring on rose leaves. There are several such records, however, under other species of the genus, and, in one case, under the variety of *C. microstictum*, wherein the spore measurements are not unlike those given for this species.

In the United States (Alabama), *C. microstictum* was reported

¹ Received from J. R. Kienholz, June 12, 1933.

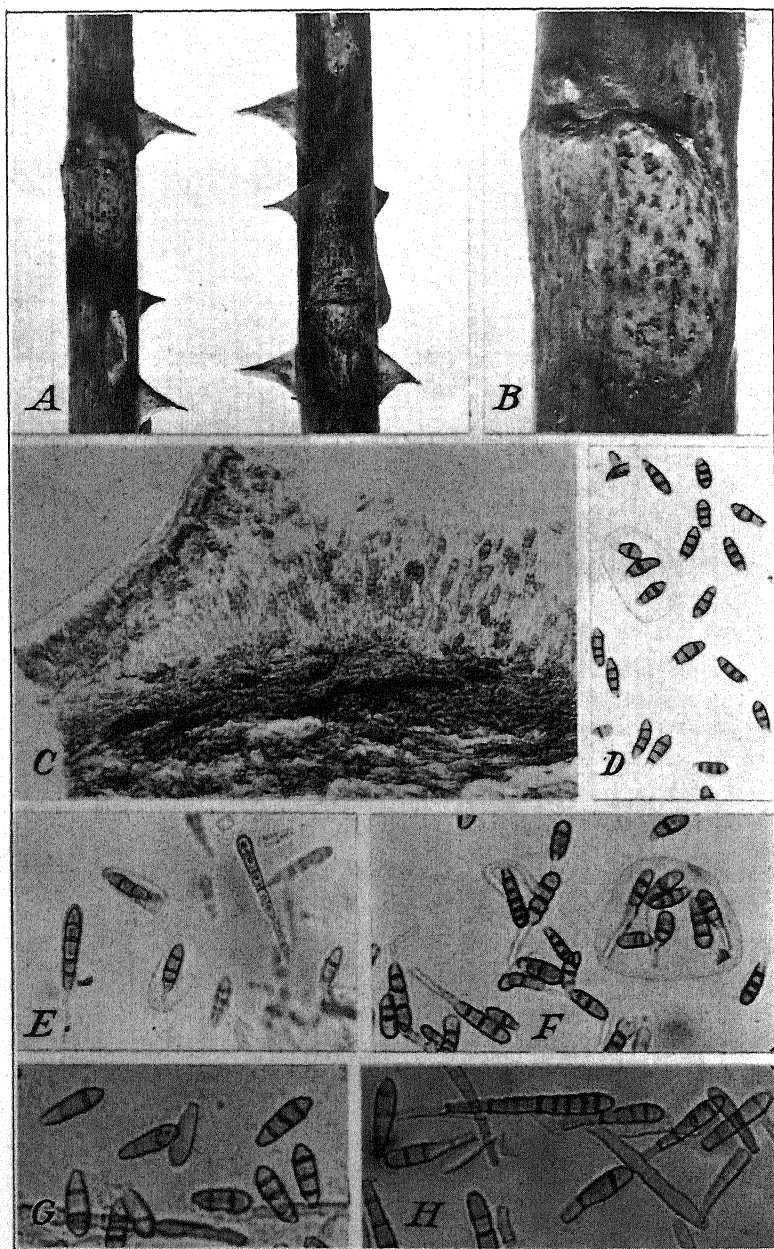


FIG. 1.

on rose as early as 1874 (2), but even yet the reports in this country of *Coryneum* on rose are few (5).

MEASUREMENTS OF CONIDIA

Conidia from the Oregon cankers (FIG. 1, A, B) measured from $12-23\ \mu \times 5-7\ \mu$ (FIG. 1, C, D); those from cankers from the eastern part of the United States, referred to in the following section, measured $13.5-21 \times 6-9\ \mu$. Those from cankers collected in Canada² and England² measured $10.8-15.5\ \mu \times 4.6 \times 6.2\ \mu$. The size of the conidia, omitted in the original description (3), are given by Saccardo as $15-17\ \mu \times 5-6.5\ \mu$ (8) and also as $16-18\ \mu \times 6-7\ \mu$ (7). Beauverie (1) found the conidia he studied to measure $12-15\ \mu \times 5-6\ \mu$.

ISOLATIONS AND GROSS CULTURAL COMPARISONS

The isolation of *Coryneum microstictum* from Oregon was made on June 16, 1933, from a specimen received on June 12. The culture from the eastern part of the United States was a reisolation by Cynthia Westcott from artificially inoculated greenhouse roses at the New Jersey Agricultural Experiment Station at New Brunswick. The fungus was recovered by means of spore dilution platings. The original isolation by Doctor Westcott was from large galls at the base of a climbing rose growing at Cornell University, Ithaca, N. Y.

A culture of *C. microstictum* var. *Mali* from apple (*Malus sylvestris* Mill.), originally from Kidd, and a culture of *C. Beyerinckii* from peach, *Prunus Persica* Benth. & Hook.), originally from Beijerinck, were obtained from the Centraalbureau voor Schimmelcultures, Baarn, Netherlands, in March, 1934. Another culture of *C. Beyerinckii* was a recent isolation by Kienholz from the Rochester variety of peach at Hood River, Oregon. In comparing the culture of *C. microstictum* from Oregon with that from the eastern United States, the three other cultures of *Coryneum* were also included as already indicated.

² Canada, Victoria Park, Niagara Falls, July 2, 1929, Cynthia Westcott. England, Grosmont (on wild rose) Sept. 17, 1930, Anna E. Jenkins. England, Royal Botanic Garden, Kew, Sept. 29, 1930, Anna E. Jenkins.

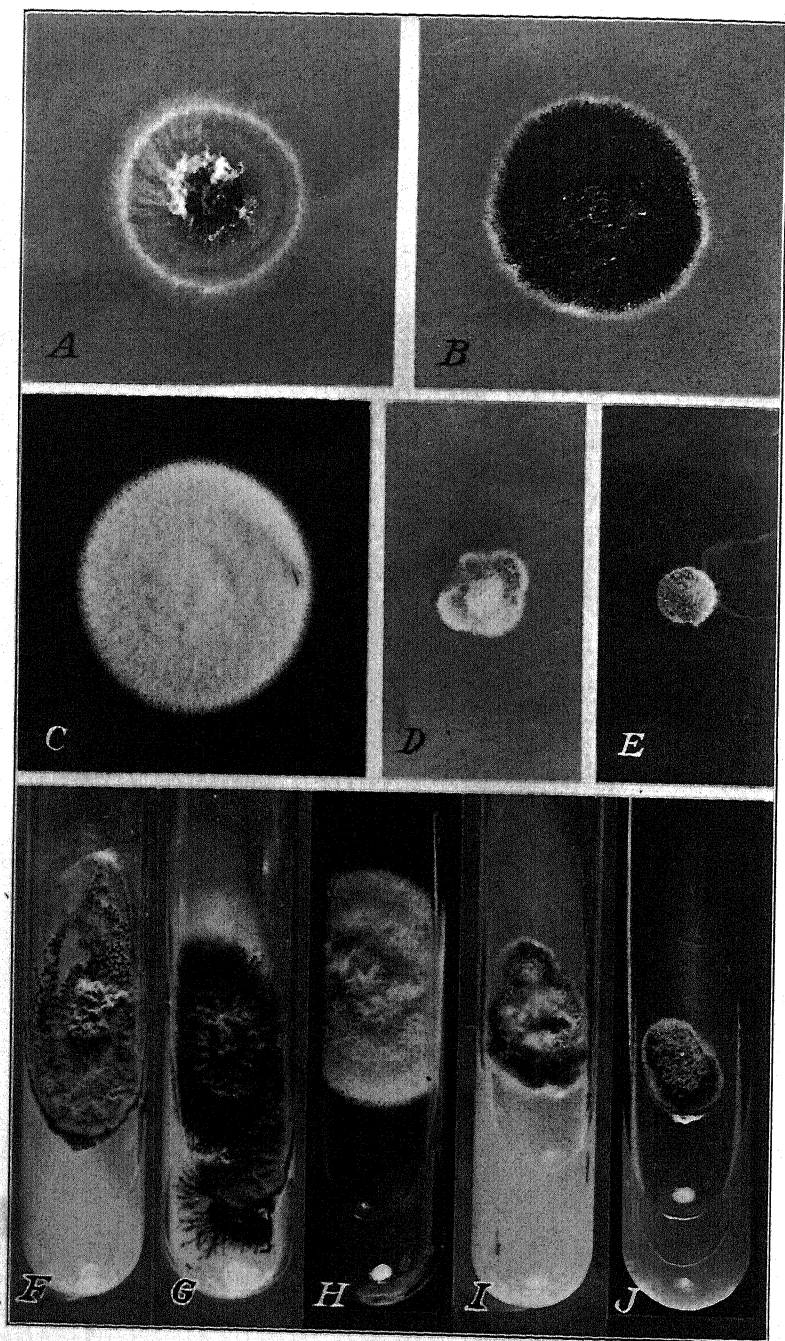


FIG. 2.

On potato-dextrose agar (Thaxter) in Petri dishes (FIG. 2, A-E) the cultures of *C. microstictum* and the variety *Mali* formed a similar group clearly separated from the two cultures of *C. Beyerinckii* by their more effuse growth as compared with the noticeably restricted growth of the latter. These cultures of *C. microstictum* and *C. Beyerinckii* from Oregon were photographed after 5 days' growth, and the other two after 8 days' growth. Color readings were made when the cultures were 4 days old. *Coryneum microstictum* from Oregon was then mostly "tawny olive,"³ the culture from rose was midway between "mummy brown" and "black," and the variety *Mali* was entirely white. The culture of *C. Beyerinckii* from Oregon was tan or buff; the other culture of this species was "light brownish olive." The marked color differences among the two cultures from rose and the culture of the variety *Mali* were chiefly or entirely due to the pale color of the conidia in the culture of *C. microstictum* from Oregon, as compared with the deeper color of the conidia of the other culture from rose, and the absence of conidia in the culture of the variety *Mali*.

The same general growth characters noted in the Petri-dish cultures were exhibited in test-tube slant cultures as shown here after 9 days' growth (FIG. 2, F-J). The potato-dextrose agar medium used for the slant cultures was made from a commercial powder (Difco). In a subsequent comparison on test-tube slants of potato-dextrose (Thaxter) agar, conidial formation was not apparent in two 3 weeks old cultures of *C. microstictum*. The cottony growth of the culture from Oregon was warm white faintly tinged with pink and of the other culture from rose was white faintly tinged with yellowish gray. In the same comparison vegetative growth at the central part of the Oregon culture of *C. Beyerinckii* was "pale grayish vinaceous" and the marginal growth "light brownish drab"; the central part of the culture from Europe was "pale drab gray," and the marginal part nearest to "tilleul buff." A week later the same cultures of the two species were less distinctive in their color differences.

³ Color readings in quotation marks are based on Ridgway (6).

COMPARISON OF CONIDIA FROM CULTURES

An examination of the Petri-dish cultures when they were 5 days old, showed most of the conidia from the culture of *C. microstictum* from Oregon to be lighter colored than those direct from the canker from which the isolation was made, and also lighter than those from the other culture from rose. Many of the conidia were also larger, and often much longer, with as many as seven cells. In a much older culture examined the conidia were definitely colored as in the other culture of *C. microstictum* (FIG. 1, E, F).

Although conidia from the two cultures of *C. microstictum* from different sources were similar, those from the two cultures of *C. Beyerinckii* were distinct. In the culture from Oregon they were short and few-celled; in the culture from Europe, they were much longer with as many as seven cells. No further study of these two strains was made, although it was noted that Smith (9) in California had observed conidia of the first type on peach bark and of the second in agar cultures.

SUMMARY

On specimens of *Coryneum microstictum* on cankered rose canes from Oregon the conidia measured essentially the same as those on rose from the eastern part of the United States; those from Canada and England were somewhat smaller. Composite measurements of conidia from all these sources ($10.8\text{--}23\ \mu \times 4.6\text{--}9\ \mu$) accord well with those previously published by others for this species on rose, which are also variable.

Culturally the fungus from Oregon resembled that from eastern United States, although it was separable in color. It was also similar to an authentic culture of *C. microstictum* var. *Mali*. These three cultures produced a noticeably less restricted growth than two cultures of *C. Beyerinckii* from different sources (Oregon and Europe) included in the same comparison, and also shown to be separable from each other.

In culture conidia of *C. microstictum* from Oregon were often larger than those direct from the cankers, and some were much longer with as many as seven cells. They were similar to the

conidia from the other culture of this species from eastern United States.

Conidia of the two cultures of *C. Beyerinckii* differed from each other. In the one from Oregon they were few-celled and relatively shorter, whereas in the one from Europe they were usually longer and sometimes contained as many as seven cells.

BUREAU OF PLANT INDUSTRY,
WASHINGTON, D. C.

LITERATURE CITED

1. **Beauverie, J.** Étude de deux maladies des Rosiers. 1. *Coryneum microstictum* Berkeley & Broome. 1st Cong. Internat. Path. Comparée Compt. Rend. 2: 968-971. illus. 1914.
2. **Berkeley, M. J.** Notices of North American Fungi. *Grevillea* 2: 153-157. 1873-4.
3. **Berkeley, M. J. & Broome, C. E.** Notices of British Fungi. *Ann. Nat. Hist.* (2) 5: 455-466. 1850.
4. **Jenkins, A. E.** *Cryptosporium* canker of rose. U. S. Dept. Agr., Bur. Plant Industry Plant Disease Repr. 18: 157. 1934.
5. **Martin, G. H. & A. E. Jenkins.** Preliminary list of fungi and diseases of roses. U. S. Dept. Agr., Bur. Plant Industry Plant Disease Repr. Sup. 63: 354-369. 1928.
6. **Ridgway, R.** Color standards and color nomenclature. 43 pp. Washington, D. C. 1912.
7. **Saccardo, P. A.** *Fungi Italici. fig. 1111.* Patavii. 1884.
8. —. *Sylloge Fungorum* 3: 775. Patavii. 1871-1886.
9. **Smith, R. E.** California peach blight. *Calif. Agr. Exp. Sta. Bull.* 191. 100 p. 1907.

EXPLANATION OF FIGURES

Fig. 1, A-F. *Coryneum microstictum*. A. On rose canes from Hood River, Oregon, J. R. Kienholz, May, 1933 ($\times 1$). B. Enlargement of cane at right in A showing conidial pustules. C. Part of a pustule ($\times 200$). D. Conidia from pustule ($\times 350$). E. Conidia from old culture of *C. microstictum* from Oregon ($\times 325$) and F, from a young culture of the fungus from Eastern United States ($\times 350$). G. Conidia of *C. Beyerinckii* from culture 5 days old from Oregon and H, from Europe ($\times 350$).

Fig. 2. Potato-dextrose agar Petri-dish cultures of *C. microstictum* from (A) Oregon and (B) Eastern United States, and (C) of the variety *Mali*; also of *C. Beyerinckii* from (D) Oregon and (E) Europe. F-J. Same cultures in the order named, after 9 days' growth on test tube slants of potato dextrose agar (Difco). (All $\times 1$.)

NOTES AND BRIEF ARTICLES

Dr. C. L. Shear, recently retired as principal pathologist in the United States Department of Agriculture, is continuing his work in mycology as a collaborator in the Division of Mycology and Disease Survey. He is devoting his attention chiefly to systematic studies of the Xylariaceae and has just spent a few weeks at The New York Botanical Garden examining the collections of this group of fungi. Dr. Shear has donated his herbarium of flowering plants to the Rocky Mountain Herbarium at the University of Wyoming. His large collection of fungi has been given to the mycological collections of the Bureau of Plant Industry. His library containing many mycological, pathological, general botanical, and miscellaneous scientific works is being offered for sale. A catalogue can be obtained by addressing him at No. 1219 North Oak St., Arlington, Virginia.

CORRECTED NOTICE

The headquarters of the Mycological Society of America have been changed from the Washington Hotel to the Warren Hotel, Illinois St., less than two blocks north of the Union Station, and approximately the same distance south of the Claypool and Lincoln which have been designated jointly as general headquarters for the A. A. A. S., the former also the headquarters for the greater number of botanical societies. The rates for rooms with baths are \$2.25-3.50 for a single room, \$3.50-5.00 for a double room.

INDEX TO VOLUME XXIX

INDEX TO AUTHORS AND TITLES

- Altstatt, G. E. & Taubenhaus, J. J. A decay of ornamental cacti caused by *Aspergillus alliaceus* 681
- Ames, L. M. A new species of *Magnusia* 222
- Backus, M. P. Phototropic response of perithecial necks in *Neurospora* 383
- Barnett, H. L. Studies in the sexuality of the Heterobasidiaceae 626
- Biggs, Rosemary. *Dipodascus uninucleatus* 34; The species concept in *Corticium coronilla* 686
- Campbell, W. A. The cultural characteristics of *Fomes connatus* 567
- Carrion, A. L. & Emmons, C. W. Sporulation of the *Phialophora* type in *Hormodendrum* 327
- Cash, E. K. *Cenangium molliusculum* 303
- & Kienholz, J. R. A new species of *Phialea* on alder seeds 81
- Charles, Vera K. A fungus on lace bugs 216
- Christensen, J. J. & Davies, F. R. Nature of variation in *Helminthosporium sativum* 85
- Chupp, Charles & Linder, D. H. Notes on Chinese Cercosporae 26
- Conant, N. F. The occurrence of a human pathogenic fungus as a saprophyte in nature 597
- Couch, J. N. Notes on the genus *Micromyces* 592; A new fungus intermediate between the rusts and *Septobasidium* 665
- Davies, F. R. & Christensen, J. J. Nature of variation in *Helminthosporium sativum* 85
- DeLamater, E. D. Crozier formation in the Gymnoascaceae: a preliminary note 187; *Eidamella spinosa* (Matruchot and Dassonville) refound 572
- Diehl, W. W. Mimicry in *Hypoxylon* 319
- Dimock, A. W. Hybridization studies on a zinc-induced variant of *Hypomyces Ipomoeae* 273; Observations on sexual relations in *Hypomyces Ipomoeae* 116
- Dodge, B. O. The conidial stage of *Peziza pustulata* 651; The perithecial cavity formation in a *Leptosphaeria* on *Opuntia* 707
- Drayton, F. L. The perfect stage of *Botrytis convoluta* 305
- Drechsler, Charles. New Zoöpagaceae destructive to soil rhizopods 229; Some Hyphomycetes that prey on free-living terricolous nematodes 447
- Emmons, C. W. Microaerophilic strains of *Actinomyces* isolated from tonsils 377
- & Carrion, A. L. Sporulation of the *Phialophora* type in *Hormodendrum* 327
- Fawcett, H. S. & Klotz, L. J. A new species of *Candelospora* causing decay of citrus fruits 207
- Fischer, G. W. Observations on the comparative morphology and taxonomic relationships of certain smuts 408

- Fitzpatrick, H. M. Historical background of the Mycological Society of America 1
- Groves, J. W. Three Dermateaceae occurring on *Nemophanthus* 66
- Hagelstein, Robert. Notes on the Mycetozoa—I 392
- Jackson, H. A. C. & Mounce, Irene. Two Canadian collections of *Cantharellus multiplex* 286
- Jenkins, A. E. *Coryneum microstictum* on rose from Oregon 725
- Josserand, Marcel & Smith, A. H. Notes on the synonymy of French and American Agarics—I 717
- Karling, J. S. A new species of *Phlyctochytrium* on *Hydrodictyon reticulatum* 178; Pascher and the genus *Asterocystis* of De Wildeman 291
- Kienholz, J. R. & Cash, E. K. A new species of *Phialea* on alder seeds 81
- Klotz, L. J. & Fawcett, H. S. A new species of *Candelospora* causing decay of citrus fruits 237
- Linder, D. H. Mycological Society of America, the summer foray, September 3-5, 1936 365; New Venezuelan Fungi Imperfecti 656; Reliquiae Farlowianae 267
- & Chupp, Charles. Notes on Chinese Cercosporae 26
- Lockwood, L. B. Hydrogen ion concentration and ascus formation 289
- McDonough, E. S. The nuclear history of *Sclerospora graminicola* 151
- Mains, E. B. A new species of *Cordyceps* with notes concerning other species 674
- Martin, G. W. Bohumil Shimek, 1861-1937 364; New or noteworthy fungi from Panama and Colombia. I 618
- May, Curtis & Verrall, A. F. A new species of *Dothiorella* causing die-back of elm 321
- Mounce, Irene & Jackson, H. A. C. Two Canadian collections of *Cantharellus multiplex* 286
- Nobles, M. K. First Canadian record of *Aleurodiscus subcruentatus* 387; Production of conidia by *Corticium incrustans* 557
- Porter, C. L. & Zebrowski, George. Lime-loving molds from Australian sands 252
- Schade, A. L. Observations on a *Monascus* isolated from rubber 295
- Seaver, Bernice. Additional data on sex reactions in monospore races of *Neurospora tetrasperma* 258
- Seaver, F. J. A mycological pilgrimage 268; Mycologia Endowment Fund 267; Photographs and descriptions of cup-fungi—XXV. *Urnula Geaster* 60; XXVI. The genus *Diplocarpa* 174; XXVII. *Pezicula* on *Cornus* 334; XXVIII. A proposed genus 678
- Shear, C. L. Mycological notes. I 355
- Smith, A. H. Flora Agaricina Danica 554; New and unusual agarics from western United States 45; Studies in the genus *Mycena*. IV 338
- & Josserand, Marcel. Notes on the synonymy of French and American Agarics—I 717
- Snell, W. H. Three thousand mycological terms 266
- Sprague, Roderick. New or noteworthy parasitic species of fungi imperfecti in Oregon 426; Undescribed species of *Cercospora* on certain grasses in Oregon and Washington 199
- Stevenson, J. A. Citrus diseases and their control 147; Fungi Exsiccati Suecici, Praesertim Upsalienses 554
- Stiffer, C. B. A new species of Tuberaceae for America 325
- Sumstine, D. R. New species of Hyphomycetes 250

- Taubenhaus, J. J. & Altstadt, G. E. A decay of ornamental cacti caused by *Aspergillus alliaceus* 681
- Tehon, L. R. Notes on the parasitic fungi of Illinois—VI 434
- Verrall, A. F. & May, Curtis. A new species of *Dothiorella* causing die-back of elm 321
- Wehmeyer, L. E. Studies of certain species of *Melanconis* on *Carpinus*, *Ostrya* and *Corylus* 599
- Whelden, R. M. Cytological studies in the Tremellaceae. IV. *Protodontia* and *Tremellodendron* 100
- Whetzel, H. H. *Septotinia*, a new genus of the Ciborioideae 128
- White, W. L. Note on *Conidiobolus* 148
- Wolf, F. T. Some sporangial variations in *Saprolegnia ferax* 226
- Zebrowski, George & Porter, C. L. Lime-loving molds from Australian sands 252
- Zundel, G. L. Miscellaneous notes on the Ustilaginales 583

INDEX TO GENERA AND SPECIES ¹

New names and the final members of new combinations are in **bold face type**. Mistakes in the spelling of scientific names encountered in text are corrected in the index.

- Achlya polyandra 226, 228
- Acrostalagmus 542
- Acrotheca 330
- Acrothecium sarcopodioides 498,
- Actinomyces 337–382; bovis 337–379, 381, 382
- Acidium Pereziae 267
- Agaricus elatior 57; immaculatus 720; marginellus 720; mitis 721, 722; myriadophyllus 719
- Albugo 153, 155, 161, 172; Bliti 152, 153, 168, 169, 172; candida 152–154, 160, 162, 169, 171; Lepigoni 172; Portulacae 152; Tragopogonis 152, 154
- Aleuria 651, 654; umbrina 651–653
- Aleurodiscus 387, 388, 391; acerinus 372; candidus 372; Oakesii 372; scutellatus 387–389; subcruentatus 387–389; 387–390
- Alternaria Citri 208
- Amanita 555; bisporiger 373; Caesarea 373; chlorinosma 373; flavoconia 373; mappa 374; rubescens 374; solitaria 373; spissa 374; verna 374
- Amanitopsis 555; vaginata fulva 374; vaginata livida 374
- Amerosporium oeconomicum 445
- Anthina pallida 375
- Arachniotus 188, 194, 196; aureus 187, 191, 195, 196
- Arachnopeziza [Trichopeziza] Aranea 371; delicatula 371
- Arcyria cinerea 370; denudata 370; digitata 370; ferruginea 393–396; ferruginea Gabriellae 395; Gabriellae 395; globosa 370; macrospora 393, 394
- Armillaria 555; mellea 374
- Arthrobotrys 447, 456, 462, 458, 469, 470, 474, 478, 485, 521, 528, 530, 540; arthrobotryoides 449, 458; **cladodes** 450, 456, 459, 461, **463**, 464, 469, 544; **conoides** 458, 459, 473, 475, **476**, 480, 518, 545; **dactyloides** 482, 483, **486**, 487, 500, 514, 516, 521, 522, 530, 535, 545, 552; longispora 474, 476, 480; **musiformis** 458, 477, 479, **481**, 484, 486, 528, 530, 545; oligospora 447, 448, 450, 454, 456–460, 462, 464–467, 469–474, 476, 477, 480, 492, 518, 542–544; recta 469, 476; rosea 469; superba 450, 451, 455–460, 462, 464, 468, 469, 474, 480, 543, 552; superba oligospora 468, 471
- Ascobolus 116, 386, 651, 714; carbonarius 651; magnificus 126, 194, 651
- Ascochyta 428; **Abroniae** 427; Achlydis 427; Boerhaaviae 427; graminiicola 440; **Hydrophylli** 428; **Negundinis** 442; Oxybaphi 427; Sorghi 435
- Ascoidea rubescens 41, 42, 44
- Aspergillus 262, 273, 300, 301, 681; alliaceus 681–685; herbariorum minor 289, 290; niger 273, 284, 285

¹ This index was prepared by Miss Bernice Seaver.

- Asterocystis* 291, 292, 294; *radicis* 293, 294
Auricularia 635; *Auricula-Judae* 626-630, 633-642, 645-647, 649; *mesenterica* 643
Bacillus 378; *prodigiosus* 300
Badhamia 399, 403, 404; *decipiens* 403; *rubiginosa* 370
Bdelospora helicoides 238
Bertia moriformis 371
Bifusella crepidiformis 267
Boletinus castanellus 373; *pictus* 373
Boletus affinis 373; *alboater* 373; *americanus* 373; *auriporus* 373; *badius* 373; *Betula* 375; *bicolor* 373, 650; *castaneus* 373; *chrysenteron* 373; *cyanescens* 373; *edulis* 650; *erythropus* 375; *felleus* 373; *gracilis* 373; *granulatus* 373; *indecisus* 373; *luridus* 650; *miniato-olivaceus* 373; *ornatipes* 373; *pal-lidus* 373; *parasiticus* 373; *punc-tipes* 373; *rugosiceps* 373; *scaber* 373; *separans* 373; *subluteus* 373
Bombardia 116, 119; *lunata* 127
Botryosphaeria 358
Botrytis 305, 306, 316, 317; *cinerea* 88, 98, 127, 128, 144, 145, 284, 305, 306; *convoluta* 306, 307, 314, 316
Bovista pila 374
Brachysporium 88
Bulgaria 678
Byssoschlamys fulva 196
Cadophora 597, 598; *americana* 598; *fastigiata* 597, 598
Calocera cornea 372
Calostoma cinnabarina 374; *Ravenelii* 374
Calvatia cyathiformis 374
Calycina macrospora 371
Camillea 319; *Sagraeana* 319
Candelospora 211, 213, 215; *Citri* 208-213-215; *ilicicola* 211, 215
Cantharellus 286, 288; *aurantiacus* 374; *cibarius* 374; *cinnabarinus* 374; *infundibuliformis* 374; *multi-plex* 286, 287; *tubaeformis* 374
Cauloglossum transversarium 677
Cenangium 70; *molliusculum* 303, 304; *Peckianum* 67, 70; *pezizoideum* 303
Cephalosporium 321, 322, 324; *Acremonium* 375
Cephalothecium 462, 469; *roseum* 462
Ceratiomyxa fruticulosa 370
Ceratostomella 116; *paradoxa* 126; *pluriannulatum* 119, 127; *Ulmi* 126
Cercoseptoria 134
Cercospora 26, 199, 201-203, 205, 206, 432, 433, 436; *ageratoides* 26, 375; *Alpiniae* 29; *Araliae* 26, 432; *atromaculans* 432; *Bromi* 204, 205; *Broussonetiae* 27, 28, 32; *Cheonis* 27, 28, 33; *clavata* 375; *congoensis* 31; *cylindrata* 28, 29, 33; *daemoni-cola* 432, 433; *ferruginea* 30; *fusi-maculans* 119; *graminis* 119, 199; *Hydropiperis* 31; *Iteodaphnes* 30; *Leguminum* 28, 30, 33; *leptosperma* 432; *leucosticta* 31; *Meliae* 30, 31; *mellicola* 31; *Miurae* 31; *Mori* 31; *Osmorhizae* 431; *pachyderma* 31; *personata* 31; *polygonorum* 31; *praegrandis* 431; *smilacina* 375; *Snelliana* 31; *subsessilis* 31; *Vani-eræ* 28, 32; *vignicaulis* 436, 439, 446; *Violae* 375
Cercosporella 119, 201, 203, 205, 206, 433, 657; *cana* 375; *Crotonis* 657; *daemonicola* 433; *herpotrichoides* 199, 201, 203, 206; *Holci* 199, 200, 201; *Huræ* 656, 658, 664; *perono-sporoides* 657; *subulata* 202, 203
Cercosporina 199, 204; *Bromi* 204
Chaetomium globosum 289, 290
Chaetoseptoria 444, 445; *Vignae* 444
Chlorosplenium 174; *Chlora* 371
Chorostate affinis 602; *decipiens* 601; *Kunzeana* 601; *mucosa* 601; *sul-phurea* 602; *suspecta* 601
Chytridium 186; *chaetophilum* 179
Ciboria 81, 128; *amentacea* 81; *nebu-losa* 372
Cintracia congensis 588, 589, 591; *patagonica* 421, 422; *togensis* 588, 589, 591; *Vanderystii* 588
Citromyces luteus 126
Cladobotryum 220; *ovalisporum* 217, 219; *replicatum* 178
Cladochytrium replicatum 178
Cladosporium 26, 31, 301, 332, 375, 590
Claudopus 555, 556
Clavaria 100, 112; *crocea* 373; *fusi-formis* 373; *Kunzei* 373; *lacinia* 373; *mucida* 373; *ornatipes* 373; *pistillaris* 373; *stricta* 373; *subbo-trytis* 373
Clitocybe 555; *albiformis* 45, 46; *albissima* 45, 46; *clavipes* 374; *gigantea* 46; *illudens* 374; *laccata* 374; *ochropurpurea* 374; *ochro-sperma* 375; *piceina* 46
Clitopilus Orcellus 374
Clypeolella Leemingii 371
Clypeosphaeria 710
Coccomyces coronatus 371; *dentatus* 371
Cochlonema 229, 232, 244; *colicho-sporum* 232, 244; *cylindricum* 243, 244, 246, 247, 249; *megaspirema*

- 235, 236, 239, 240, 248; *odonto-*
sperma 229, 230, 233, 234, 237, 247,
248; *verrucosum* 232, 244
Coleosporium Solidaginis 372
Collema 145; *pulposum* 145
Colletotrichum 144, 436
Collybia 347, 555, 647, 718; *albi-*
flavida 374; *confluens* 374; *dryo-*
phila 374; *lilacea* 718, 719, 723;
myriadophylla 718, 719, 723; *ore-*
gonensis 47, 48; *platyphylla* 374;
racemata 374; *rugulosiceps* 342;
strictipes 374; *umbonata* 46, 47
Comatricha flaccida 405; *typhoides*
370
Conidiobolus 148; *villosus* 148
Coniothecium 663
Coniothyrium caryogenum 442; *di-*
plodiella 363; *radicicola* 442
Coprinus 648; *disseminatus* 648;
lagopus 644, 648; *micaceus* 648;
Rostrupianus 648; *sphaerosporus*
648; *sterquilinus* 692
Cordyceps 674, 677; *capitata* 371;
herculea 677; *Melolonthae* 677;
michiganensis 676; *militaris* 371;
stylophora 676; *superficialis* 676;
unilateralis 674; *viperina* 674, 675
Coronophora 363; *ootheca* 361
Corticium 688, 689, 706; *alutaceum*
696-705; *atrovirens* 373; *coronilla*
687, 688-694, 696; *diademiferum*
689; *incrustans* 557-559, 561, 562,
564, 565; *niveocreteum* 689; *octo-*
sporum 688; *radiusum* 696, 697;
roseopallens 557; *vagum* 373
Cortinari *armillatus* 374; *bolaris*
374; *corrugatus* 374; *purpurascens*
374; *semisanguineus* 374
Coryne sarcoides 372; *urnalis* 372
Coryneum 725, 727; *Beyerinckii* 725-
731; *microsticta* 725-731; *micro-*
sticta Mali 727, 729-731
Craterellus Cantharellus 373; *May-*
dis 402
Craterium *Maydis* 402
Crepidotus dorsalis 374; *malachius*
374
Cribraria minutissima 396; *oregana*
395; *purpurea* 370
Crinipellis 555
Crucibulum vulgare 374
Cryptodiaporthe 616; *galericulata*
616
Cryptospora 605; *bitorulosa* 601, 603,
605; *minimum* 725; *nigroannulata*
601
Cryptosporium 731
Cryptostictis Mariae 375
Ctenomyces serratus 197, 574, 576,
579, 580
Cudonia lutea 372
Cyathicula coronata 372
Cyathus stercoreus 374; *striatus* 374
Cyclomyces Greenei 373
Cylindrocladium 211; *scoparium* 211
Cylindrosporium 443; *acerinum* 375;
saccharinum 375
Cyphella capula flocculosa 373
Cystoderma 555
Cystopus candidus 172
Cytospora 322, 605; *carnea* 606
Dactylaria 447, 485, 514, 527, 530;
acicularis 516; *brochopaga* 486, 514,
515, 517, 535, 538, 549; *candida*
447, 502, 523, 525-527, 550; *echino-*
phila 516; *mucronulata* 516; *oogena*
517; *orchidis* 516; *polycephala* 527,
529, 530, 539, 551; *pulchra* 448,
517; *purpurella* 516; *thausasia* 450,
458, 490, 518, 519, 522, 528, 550,
552
Dactylella 247, 447, 506, 532, 539,
541; *asthenopaga* 449, 450, 496,
497, 498, 532, 538, 539, 547;
bembicodes 449, 487, 489, 491, 500,
510, 512, 514, 520-522, 532, 534,
535, 546, 552; *brochopaga* 517;
ellipsospora 447, 490, 492, 493,
495, 496, 499, 500, 502, 509,
512, 521, 526, 531, 546; *gephy-*
ropaga 490, 508, 511, 512, 520-
522, 549, 552; *leptospora* 503,
505, 507, 523, 548; *lysiopaga* 495,
499, 501, 503, 504, 506, 523, 524,
526, 547; *minuta* 448; *minuta*
fusiformis 448, 506, 507; *passa-*
lopaga 241, 244, 472, 507; *pulchra*
448; *Rhombospora* 539, 540, 552;
tenuis 538, 539, 552; *tylopaga* 203,
510
Dactylium candidum 526, 527
Daedalea confragosa 373; *quercina*
373
Daldinia concentrica 371
Darlucula Filum 375
Dendrodochium compressum 375
Dermatea 70, 75, 303; *brunneo-*
pruinosa 372; *Cerasi* 70; *Corni* 334,
335; *molliuscula* 304; *Peckiana* 66,
67, 68, 74-76, 79; *Prunastri* 372;
purpurascens 372
Dermoloma 555
Diachea leucopodia 371
Diaporthe 606, 617; *affinis* 602;
bitorulosa 601, 603, 604; *Bloxami*
602, 603; *Carpini* 601, 605; *car-*
pinicola 591, 601, 603, 605, 606;
carpinigera 601; *decipiens* 601, 603;
elaeostroma 601; *Ellisii* 601-603,
605; *farinosa* 601, 606; *hyperopta*
601; *Kunzeana* 601, 604, 605;
leucostoma 601; *mucosa* 601; *nigro-*

- annulata 601; *Ostryae* 601, 603, 609; *ostryigena* 601; *sulphurea* 602, 606
Diatrype carpinigera 601; *Stigma* 372
Diderma floriforme 371; *testaceum* 371
Didymium 397; *anomalum* 397; *nigripes* 371; *squamulosum* 406; **Sturgisii** 397
Dilophospora 430; *Alopecuri* 430; *graminis Holci* 430
Dimerosporium Galactis 371; *Tsugae* 371
Diplocarpa 174-176; **Bloxami** 177; *Curreyana* 175-177
Diplodia Rubi 441; *Ruborum* 441
Dipodascus 43, 44, 620; *albidus* 34-37, 39, 41, 42-44, 619; **uninucleatus** 34, 41, 42-44, 620
Discella 356; *effusa* 355
Discodiaporthe 606; *xanthostroma* 601
Discosia rugulosa 375
Discosporium 605, 606, 616, 617; *deplanatum* 605, 606; *sulphureum* 606
Dothiorella 321, 322; *irregularis* 606; **Ulmi** 321, 322-324
Durandia 78, 79; *Fraxini* 78
Durandiella 78, 79; **Nemopanthis** 66, 75, 76, 79
Eccilia 555, 556
Eidamella Actoni 573, 580; *spinosa* 197, 572-574, 577-580, 582
Elaphomyces cervinus 371
Elsinoe Fawcettii 147
Encelia Bloxami 177
Endocochlus 235; *asteroides* 231, 237; *brachysporus* 237; *gigas* 231, 235, 237
Endomyces 42
Endothia parasitica 371
Enteridium Rozeanum 371
Entoloma 555, 556
Entomosporium maculatum 375
Entophlyctis 294
Eremascus albus 196
Erysiphe 116
Eutypa spinosa 371
Exidia 114, 635, 649; *glandulosa* 626-630, 632, 639, 640, 642-646, 649; *nucleata* 626-628, 630-632, 643-645, 649; *recisa* 626-628, 630, 631, 642-645, 649; *saccharina* 626-628, 630, 631, 642, 644-646, 649
Exobasidium Vaccinii 373
Favolus alveolaris 373
Fistulina hepatica 373
Flammula polychroa 374
Fomes 567; *applanatus* 373; *connatus* 373, 567, 568, 570, 571; *fomentarius* 373; *igniarius laevigatus* 373; *pinicola* 373, 648
Fuligo 399; *cinerea* 399; *septica* 398-400, 405; *septica candida* 399
Fusarium 86, 98, 124, 126, 241, 247, 273, 274, 284, 285, 301, 309, 504, 507, 541; *javanicum* 116; *moniliforme* 86, 99, 127
Fusicladium Robiniae 375
Fusicoccum 616; *Carpini* 605; *Kunzeanum* 605
Galera tenera pilosella 375
Gelasinospora 651; *tetrasperma* 264
Gelatinosporium betulinum 375
Geoglossum glabrum 372; *hirsutum* 372
Gibberella 116; *Saubinetii* 88, 89, 98, 99
Gibberidea 358, 360, 361; **abundans** 361; **Heliopsisidis** 361; *obducens* 359, 361; **paraguayana** 361; *Visci* 361
Gloeosporium 138, 436, 443; *fructigenum* 144; *Hydrophylli* 428; *podophyllinum* 130, 133, 135, 144, 145; *podophyllum fructigenum* 144; *septarioides* 443
Glomerella 116, 127; *cingulata* 355, 436; *Lindemuthiana* 436; *Lycopersici* 119, 127; **vignicaulis** 435, 439, 446
Gloniopsis Smilacis 371
Glonium stellatum 371
Gnomonia Coryli 371
Godronia 78, 79; *Nemopanthis* 75
Godroniopsis 75; **Nemopanthis** 66, 71, 74-76, 79; *quernea* 75, 372
Gomphidius 59; *oregonensis* 48; *roseus* 47; *subroseus* 47
Gonatobotrys 540
Gonatobotryum maculicola 355
Grandinia 688, 699, 702; *Brinkmannii* 689, 704; *raduloides* 373
Graphium Ulmi 126
Gymnoascus candidus 191-194; *gypseum* 197, 578, 580; *Reessii* 188, 191-194, 197, 573, 574; *ruber* 533, 574; *setosus* 573-575
Gymnoconia Peckiana 372
Gymnopus 724
Gymnosporangium 77; *globosum* 372
Haplosporangium 618; *bisporale* 618, 619; *decipiens* 618, 619; **lignicola** 618, 619, 623, 625
Helicosporium lumbricopsis 624
Helminthosporium 85-89, 91-93, 95-98, 126; *gramineum* 88, 89, 98, 99; *sativum* 85-99, 480; *tetramera* 87, 88

- Helotium citrinum* 372; *epiphyllum* 372; *Scutula* 372
Helvella atra 372; *crispa* 372; *infula* 372
Hemitrichia abietina 400; *Serpula* 371; *stipitata* 371; *vesparium* 371
Hendersonia 707, 709, 710, 713, 715; *Opuntiae* 707, 708, 710, 714-716
Hercospora 356, 358; *Tilliae* 356
Heterotrichia Gabriellae 393, 395
Hirsutella 217, 220; **verticillioides** 218-220
Hobsonia gigaspora 623-625
Hormodendrum 327, 328, 330-332; *compactum* 328, 330-333; *Langeroni* 328; *pedrosoi* 328, 330-333
Hyaloria 622; *Pilacre* 620, 623, 625
Hydnotria 326; *carnea* 325, 326; *Tulasnei* 325, 326
Hydnum adustulum 373; *adustum* 373; *Caput-ursi* 373; *coralloides* 373; *erinaceum* 373; *repandum* 373; *rufescens* 373; *zonatum* 373
Hygrophorus borealis 374; *chlorophanus* 374; *coccineus* 374; *conicus* 374; *marginatus* 374; *miniatus* 374; *psittacinus* 374
Hymenochaete rubiginosa 373; *spretia* 373; *tabacina* 373
Hyphochytrium Hydrodictyi 179, 186
Hypholoma capnoides 48; *dispersum* 48, 59; *fasciculare* 48
Hypochnus 148; *botryoides* 373; *ferrugineus* 373; *isabellinus* 373; *pannosus* 373
Hypocrea gelatinosa 371; *lenta* 371; *rufa* 371
Hypoderma commune 371
Hypomyces 116; *Ipomoeae* 116, 118-121, 124, 125, 274, 275, 277, 281, 282, 283, 284; *rosellus* 127
Hypoxylon 319; *caries* 371; *coccineum* 371; *cohaerens* 319, 371; *marginatum* 319, 371; *multiforme* 371; *rubiginosum* 371
Inocybe 59; *hystrix* 374; *lilacina* 374
Ionomidotis irregularis 174
Kuehneola Uredinis 372
Laccaria 555
Lachnea aurantiopsis 680; *hemisphaerica* 375
Lachnella diplocarpa 175
Lachnum ciliare 372; *virgineum* 372
Lactarius camphoratus 374; *cinereus* 374; *corrugis* 374; *croceus* 374; *deceptivus* 374; *Gerardii* 374; *lig-nyotus* 374; *luteolus* 374; *Peckii* 374; *pergamenus* 374; *piperatus* 374; *subpurpureus* 374; *theiogalus* 374
Lamprospora trachycarpa 372
Lasiosphaeria ovina 371
Lenzites betulina 373
Leocarpus fragilis 371
Leotia lubrica 372; *lubrica* *Stevensoni* 372
Lepiota 555; *acutisquamosa* 374; *amianthina* 374; *cristata* 374; *metulisporea* 374; *Morgani* 650; *procera* 374; *rugoso-reticulata* 374; *solidipes* 49, 50
Leptonia 555
Leptosphaeria 707, 709-712, 714, 715; *fusispora* 371; *Opuntiae* 708, 714, 715; **Querci** 446; *sicula* 708
Leucobolbitius 555
Limacella 555; *lenticularis* 555
Lycogala conicum 371, 400, 401; *epidendrum* 371, 401; *exiguum* 371, 400, 401
Lycoperdon atropurpureum 374; *Curtisii* 374; *fuscum* 374; *gemmatum* 374; *marginatum* 375; *pyriforme* 375; *subincarnatum* 375
Macrophoma 440, 441; *arens* 440; *conica* 441; *crustosa* 440 *erumpens* 440; *graminella* 440; *Hennenbergii* 440; *oblongata* 438, 440; *Phlei* 440; **Rubi** 441; *Sacchari* 440; **secalina** 438-440, 446; *suspecta* 440; *Zeae* 440
Magnusia 222, 223, 225, **brachytricha** 223, 224, 225; *nitida* 222-225
Malacostroma irregulare 606
Marasmius 555, 647, 718; *androsaceus* 374; *cohaerens* 374; *confluens* 374; *dichrous* 374; *foetidus* 374; *insititius* 374; *oreades* 374; *resinosus* 374; *rotula* 374; *semi-hirtipes* 374; *siccus* 374; *subnudus* 374
Marssonina Martinii 375; *ochroleuca* 375
Mastigosporium 203, 205
Melanconis 358, 599, 602, 604, 606, 608, 612, 613, 616; *Alni* 616; *bitorulosa* 601; *chrysostroma* 601, 603, 605; **flavovirens** 602; *hyperopta* 600, 603; *marginalis* 616; **Ostryae** 601, 603, 609-611, 615-617; **platystroma** 613, 615, 616, 617; *sulphurea* 600, 602, *Tilliae* 356; *xanthostroma* 600, 602, 606, 607, 610, 611, 615-617
Melanconium 602, 603, 605-607, 609-611, 613-617; *bicolor ramulorum* 602, 606, 615; *deplanatum* 605; *microsporium* 602; *triangulare* 602, 603, 605
Melogramma 358, 359, 360; *vagans* 359, 360

- Microascus* 713
Microglossum rufum 372
Micromyces 592; **longispinosus** 592, 593, 594, 596; *Petersenii* 592; *Spirogyrae* 592; *Zygogonii* 592-596
Micropera 70; *caespitosa* 66, 69, 71, 73, 74; *Nemopanthis* 67; *stellata* 66, 67, 70, 74, 75, 79
Microsphaera Alni 371
Mollisia cinerea 372
Monacrosporium 447, 462, 469, 472, 506, 539; *elegans* 448, 488, 490, 495, 512, 522; *leporinum* 495, 548; *megasporum* 448, 522; *ovatum* 448, 490; *oxysporum* 448, 506, 507; *sarcopodioides* 498; *subtile* 506, 507
Monascus 296-302; *Barkeri* 296, 302; *olei* 295, 302; *purpureus* 295-302; *ruber* 295-301
Monilia 126; *sitophila* 127, 715
Monilinia 128
Monosporidium repens 466, 492
Montagenella Heliopsisidis 359
Mucidula 555
Mucilago spongiosa 400; *spongiosa solida* 399
Mucrosporium 211
Mycena 45, 59, 342, 354, 555; *alcalina* 352, 556; *atroalboides* 556; *avelanea* 349; *Berkleyi* 343; *brevipes* 344, 345, 353; *capillaripes* 556; *cholea* 556; *citrinomarginata* 340; *codoniceps* 343; *codoniceps aciculata* 339, 344; *elegantula* 345, 346; *fellea* 556; *filipes* 339; *flavifolia* 340; *Font-Querii* 339; **fuscoocula** 338, 339; *galopoda* 556; *Grantii* 343; *immaculata* 719, 720, 723; *inclinata* 346; *intertexta* 349; *Iris* 556; *Jacobi* 348, 556; *laevigata* 346; *latifolia* 556; *Leaiana* 341, 342, 374; *leptocephala* 345; *longipes* 343; *magna* 343; *megaspora* 342, 343; *metata* 349; *niveipes* 347, 348, 353; **olivaceobrunnea** 339, 352, 353; *pectinata* 349; *pinetorum* 556; *plicosa marginata* 556; *polygramma* 348, 350, 351; *polygramma albida* 348; *praelonga* 350; *pseudogalericulata* 348, 556; *pullata* 350; *pureofusca* 346; *radicatella* 347; *rubromarginata* 346; *rubromarginata Laricis* 346; **rugulosiceps** 342, 343; *sepia* 556; *subcalina* 352; *subalpina* 348; **subsupina** 340, 341, 348; *supina* 341; *tenuicula* 349; **texensis** 339, 341; *tintinnabulum* 351, 352, 354
Mycenella 555
Mycosphaerella Holci 434, 439, 446
Myiocopron smilacis 375
Myriangium 669, 671; *Duriaei* 271
Myxosporium 334, 337, 616; *deplanatum* 605; *sulphureum* 606
Naucoria 45; **attenuata** 49, 51, 58; *caespitosa* 54; *cucumis* 55; *effugiens* 721; *elatior* 45, 46, 57; *festiva* 55; *flava* 52; *innocua* 58; *Jennyae* 52; **Kauffmani** 52-54, 56; *lugubris* 54, 56, 59; *Myosotis* 57; *obtusa* 58; *radicata* 52, 57; *Similis* 52; *stictica* 58
Naumovia 358, 359, 361; *abundans* 358
Nectria cinnabarina 371; *lactea* 371
Neocarcangelia 361; *ootheca* 362
Neurospora 116, 119, 120, 125-127, 145, 262, 264, 651, 652, 714; *sitophila* 116, 119, 123, 258, 264, 383-386; *tetrasperma* 119, 123, 126, 258, 259, 262, 263, 264, 277, 282
Nolanea 555, 556
Odontia bicolor 373; *lactea* 373
Oedocephalum 652, 653
Olpidiaster 291, 292
Olpidium 291, 292, 293, 294; *Brassicae* 294; *radicale* 294; *radiciculum* 293
Omphalia 354, 555, 719, 721; *angustispora* 719; *campanella* 374; *curvipes* 352; *fibula* 374; *gracilis* 719, 720, 723; *marginella* 720, 721, 723, 724; *marginella rugosodisca* 721, 723; *rugosodisca* 720, 721; *semi-vestipes* 352, 354
Ophiobolus 116; *Cariceti* 127; *graminis* 126; *sativus* 85
Ophiocordyceps 674, 677; *macularis* 677
Ophiodothella Vaccini 371
Orbilbia xanthostigma 372
Otidea grandis 372; *leporina* 372
Ovularia vancoveriae 431
Pachytrichum Guazumae 659
Panellus mitis 721-723
Panus 555; *bacillisporus* 721-723; *stypticus* 374
Passalora 26
Patella albida 372; *scutellata* 372
Paxillus involutus 374; *rhodoxanthus* 374
Paxina hispida 372
Peckii *viridis* 371
Pedilospora 447; *dactylopaga* 472, 532, 541
Penicillium 116, 126, 197, 273, 300, 580; *glaucum* 285; *javanicum* 289, 290
Peniophora coccineofulva 373; *cremea* 373; *Peckii* 373

- Perichaena 407; corticalis 401, 402; depressa 401, 402; marginata 401; quadrata 401, 402
 Periconia 659; byssoides 659; circumata 660; Citharexylis 660; Coffeae 660; Commonsii 659; epiphylla 660; Guazumae 659, 660; Langloisii 659; nigriceps 659; Palmeri 660; pycnospora 659, 660; **Toroi** 657-660, 664
 Peridermium guatemalense 267
 Peronospora 152; alinearum 161; effusa 152, 161, 169; Ficariae 153, 171; Halstedii 7; parasitica 172; setariae 172; viticola 7
 Pestalotia 375; macrotricha 375
 Pezicula 75, 334; acericola 372; **Corni** 334, 335, 337; cornicola 336, 337; minuta 372; rhabarbina 334, 337; rhabarbina Rubi 334; Rubi 372
 Peziza 148; aurantiopsis 678, 680; cerea 654; diplocarpa 174, 175; domiciliana 148; Fraxini 79; pustulata 652-654; querneae 75, 79; vesiculosa 654
 Pezizella Lythri 707
 Phaeocollybia 45; lugubris 59
 Phialea 81, 82; alniella 81; amenti 81; dolosella 372; **fastigata** 598; phyllophila fagicola 372; Scutula Pteridis 372; **seminicola** 82; viridifusca 81
 Phialoconidiophora guggenheimia 328
 Phialophora 328, 330-332, 598; **brunescens** 598; **Lagerbergii** 598; **Melinii** 598; **obscura** 598; **repens** 598; **Richardsiae** 598; verrucosa 328, 330, 331, 333, 597, 598
 Phillipsia 678
 Phleospora 133, 134, 146
 Phlyctochytrium 178, 179; chaetiferum 179-181, 183-185; Hydrodictyi 179
 Pholiota 566, 724; acericola 374; albocrenulata 722-724; aurivella 565, 566; fusca 722, 723; Johnsoniana 374; polychroa 648; squarrosoides 374; subsquarrosa 374
 Phoma 322; castanea 375
 Phomatopora Wistariae 436
 Phomopsis 606
 Phragmidium Potentillae 372, 375
 Phyllosticta 435; **atomata** 437, 438; **Barssii** 426, 427; minutissima 375; plantaginella 438; plataginicola 438; Plantaginis 438; sorghina 435; vagans 375
 Phyllostictina carpogena 707
 Physalospora 358
 Physarum 402, 404; auriscalpium 402-404; globuliferum 371; leucopus 371; Maydis 402, 403; nutans 371; oblatum 402, 403; ovisporum 404; rubiginosum 404
 Physomyces heterosporus 295, 302
 Pilacre faginea 648
 Pileolaria extensa 267
 Pilobolus 385
 Pistillaria clavulata 373
 Plascosphaeria Beckerae 587
 Plasmodiophora Brassicae 294
 Plasmopara 152; alpina 152, 172
 Pleomassaria rhodostoma 708
 Pleospora 708; leptosphaerioides 708
 Pleurage 116, 119, 125; anserina 119, 125-127, 145, 194
 Pleurostoma 361, 362; Candollei 362
 Pleurotus 721; applicatus 374; corticatus 565, 566; mitis 721; ostreatus 374; pinsitus 562, 564-566; porrigens 374; sapidus 374
 Pluteus 555; cervinus 374
 Podostroma alutaceum 371
 Polyozellus 286; multiplex 286, 287
 Polyporus 371; albellus 373; cinabarinus 373; compactus 373; corticatus 565; dichrous 373; elegans 373; fragilis 373; giganteus 373; guttulatus 373; hirsutus 373; immitis 373; nidulans 373; ostraeformis 647; pargamenus 373; semipileatus 373; squamosus 565; Tsugae 373; versicolor 373
 Polystictus hirsutus 647
 Polythrincium Trifolii 375
 Poria candidissima 373; semitincta 373; versipora 373
 Propolis faginea 371
 Protascus 540; subuliformis 459
 Protodontia 100, 101, 111-114; uda 101, 102, 114
 Protohydnum lividum 100, 112
 Prunulus 354
 Psalliota diminutiva 374; sylvatica 375
 Psathyra fagicola 59; **pelliculosa** 58
 Pseudodiscosia 203, 206; Avenae 205
 Pseudomeliola Menthae 361
 Pseudopeziza Ribis 372
 Psilocybe Foeniseii 374; ochraecephus 45, 48, 49
 Puccinia atropuncta 372; Cyripedii 372; Derris 534; fidelis 267; graminis 423; Heucherae 372; Malvacearum 7; Menthae 372, 375; rubigovera 423; Schedonnardi 372 375; Tetramerii 267; Violae 372
 Pucciniastrum Hydrangeae 372; Myrtilli 372
 Pucciniopsis Anacardii 661; caffra 661; Caricae; Lonchocarpi 658, 660, 664; quercina 661
 Pyronema 194, 714; avellaneum 196; confluent 194-197
 Pythium 229, 235; Butleri 510, 538, 539; ultimum 244, 538, 539

- Rabenhorstia Tiliae 356
 Ramularia 431; *Giliae* 430; *Malvastris* 658, 661, 664; *Oxalidis* 375; *Vancouveriae* 431
 Ravenelia Farlowiana 267; *versatilis* 267
 Rhinotrichum *Noblesiae* 250; *tennerum* 250
 Rhizophidium Mindeni 179; *simplex* 185
 Rhizopus *nigricans* 455
 Rhodophyllus 555, 556
 Rhytisma *Salicis* 371
 Romellia 363
 Rosellinia *purpureofusca* 371; *subiculata* 371
 Rosenscheldia 358–361; *Heliopsisidis* 358, 360; *obducens* 361; *paraguayana* 359, 361
 Russula *crustosa* 374; *decolorans* 374; *emetica* 374; *flava* 374; *foetens* 374; *fragilis* 374; *lactea* 374; *sericeonitens* 374; *simillima* 374; *variata* 374; *violacea* 374
 Sabouraudites *gypseum* 197, 580
 Saprolegnia 226, 228; *ferax* 226–228; *Thureti* 226
 Sarcoscypha *floccosa* 372; *occidentalis* 372
 Schizoparme 707
 Schizophyllum *commune* 374
 Schizothyrium *Gaultheriae* 371
 Scleroderma *aurantia* 375
 Sclerodermis 79
 Sclerospira 154, 155, 159, 160, 161, 163, 169, 171, *graminicola* 151–153, 155, 156, 162, 167, 168, 170–172; *Sorghi* 172
 Sclerotinia 64, 116, 119, 125, 128, 145, 305, 306, 312, 316, 317, 385; *convoluta* 313, 314, 316; *Fuckeliana* 305; *Galanthi* 305, 308–310, 312, 317; *Geranii* 305; *Gladioli* 119, 127, 143, 145, 308, 310, 317
 Sclerotium *concava* 707; *Porri* 306, 317; *Ricini* 306, 317; *sclerotiorum* 144
 Scolecotrichum *graminis* 199
 Scopulariopsis 715
 Scutellinia *aurantiopsis* 680
 Sebacia 114, 619, 648, 649; *globospora* 114, 649; *incrustans* 372
 Septobasidium 665, 673; *castaneum* 666, 669; *Curtisii* 672; *pseudopedicellatum* 669; *sinuosum* 669
 Septogloeum 130, 134, 145; *Equiseti* 445; *podophyllinum* 130, 131, 133, 135, 145
 Septoria 443, 444, 445; *Argophyllae* 430; *Drygalski* 429; *dryina* 444; *Poseyi* 429; *quercicola* 444; *quercina* 444; *Querciti* 444; *Quercus* 443, 444; *Rubi* 375; *Rubi pallida* 375; *Stenhammariae* 429; *umatillensis* 429, 430
 Septoriopsis 130, 134, 145; *podophyllina* 133, 134
 Septotinia 134; *podophyllina* 131, 132, 135, 137, 141, 144
 Sistotrema 689; *confluens* 689; *cornilla* 689, 690
 Solenia *fasciculata* 373
 Sordaria *coprophila* 543; *fimiseda* 543
 Sorosporium 583, 584, 587, 590; *Aristidae* 584; *Beelii* 590; *Bornmulleri* 584; *consanguineum* 584; *ischaemoides* 587; *kinshaensis* 589, 591; *kinshasaensis* 590; *Panici* 590; *Panici kinshasaensis* 589, 590; *Wildemanianum* 589, 590, 591
 Spathularia *velutipes* 372
 Sphaeroloma *Fawcettii* 147
 Sphaerolotheca *Kenya* 586; *Ruprechtii* 586
 Sphaerella *Ceres* 435
 Sphaeria *atrovirens* 356; *carpinigera* 601; *herculea* 677; *Lemaneae* 543; *mucida* *rostellata* 362; *oospora* 361; *Tiliae* 356; *xanthostroma* 600
 Sphaerobolus *stellatus* 375
 Sphaerographium *stellatum* 67
 Sphaeronema 74, 79, 375; *acerina* 375; *caespitosum* 70, 71, 73, 74; *Peckii* 66, 70, 71, 74, 75, 79; *stellatum* 67, 69, 70, 74
 Sphaeropsis 322; *Rosarum* 441; *rubicola* 441; *Uvarum* 363
 Sphaerulina *intermixta* 654
 Sporocye *Azaleae* 375
 Sporodesmium *concinnum* 375; *Peziza* 375; *polymorphum* 375
 Sporormia 711, 715; *leporina* 713, 715
 Stagonospora 428; *Achlydis* 428; *Glyceriae* 428
 Stagonosporopsis 428
 Steccherinum *ochraceum* 373
 Stemonitis *splendens* 399, 405; *splendens flaccida* 405; *splendens Webberi* 405; *Webberi* 405
 Stemphylium 375
 Stephanoma *strigosum* 375
 Stereum 388, 391; *Burtianum* 373; *fasciatum* 373; *hirsutum* 373; *rameale* 373; *subcruentatum* 388
 Stictis *quercifolia* 371; *radiata* 371
 Stigmella 663; *graminicola* 662, 663, 664; *Sacchari* 663, 664
 Stilbum *giganteum* 375
 Streptothrix *atra* 375; *fusca* 251; *Mounceae* 250
 Strobilomyces *strobilaceus* 373
 Stylopaga 541; *hadra* 453; *leiohypha* 453

- Synchytrium decipiens* 371
Thecaphora 583; **leptideum** 583, 584
Thelaphora vialis 373
Thielaviopsis paradoxa 126
Thyrsidium botryosporium 375
Tilletia Ayresii 586; *heterospora* 586;
 levis 423; *Tritici* 414, 423
Tinea capitis tropicalis 580
Tolyposporium 584; **leptideum** 583
Torrubiella hemipterigena 217
Trametes cinnabarina 565
Tranzschelia Pruni-spinosae 372
Tremella 114, 648; *carneopalba* 372;
 frondosa 372
Tremellodendron 100, 110, 111-114;
 candidum 106, 107, 114, 372;
 cladonia 372; *gelatinosum* 372; *pal-*
 lidum 372
Trichia alpina 406; *cascadensis* 406;
 contorta 371, 401, 406, 407; *con-*
 torta inconspicua 407; *contorta*
 iowensis 407; *favoginea* 371; *in-*
 conspicua 371, 407; *iowensis* 407;
 ovata 400
Trichocoma paradoxa 620
Tricholoma 555; *sulphureum* 374
Trichophyton 580; *Currii* 578
Trichoseptoria 445; *Alpei* 445
Trichothecium 447, 462, 469, 472,
 536; *inaequale* 448, 536; **poly-**
 brochum 535, **536**, 537, 551;
 roseum 462, 469, 470-472, 536, 541;
 roseum arthrobotryoides 458, 471
Tripasporina 534; **aphanopaga** 449,
 531, 533, **534**, 551; *uredinicola* 534
Trogia crispa 374
Tulasnella 648
Tympanis 78; *Fraxini* 78, 79; *Nemo-*
 panthis 70, 75, 78.
Typhula filicina 373

Uredinella 665; **coccidiophaga** 665,
 666, 673

Urnula 678; *Geaster* 60, 61, 63-65,
 678
Uromyces Hyperici 372; *Silphii* 372,
 376
Ustilago 586, 587, 590; *Agropyri* 421;
 Aristidae 584; *Beckerae* 586, 587;
 Bromi-arvensis 422; *Bromi-mollis*
 422; *bromivora* 409, 411-413, 415-
 421, 423-425; *bromivora macro-*
 spora 411, 414-418, 421, 423;
 bromivora microspora 423; *bullata*
 410, 413-416, 418, 419, 421, 423,
 424; *Carbo vulgaris bromivora* 421;
 Cynodontis 584, 585; *Digitariae*
 584; *Dregeana* 585; *heterospora*
 586; **Hitchcockiana** 585; *Holwayi*
 421; *Hordei* 411; *ischaemoides* 587;
 Lorentziana 408-410, 414-421, 423,
 424; *paraguariensis* 585; *patagonica*
 422; *Rabenhorstiana* 584; *Setariae-*
 aureae 587; *striaeformis* 421, 424;
 ugandensis 590; *Vanderystii* 588;
 Zeae 97, 99
Ustilina vulgaris 371

Valsa bitorulosa 600; *chrysostroma*
 600; *Ellisii* 601; *flavovirens* 602;
 olivaestroma 602; *xanthostroma*
 600
Valsaria bitorulosa 600
Venturia Rhododendri 371
Verticillium 220; *hemipterigena* 217,
 219
Volvaria 555

Wolfina 678; **aurantiopsis** 679, 680

Xylaria corniformis 371; *Cornu-*
 Damae 371

Zoopage 229, 241; *nematospora* 238;
 phanera 238; **tryphera** 241, 242,
 Zoophagus insidians, 466, 541-543